The detection of colour-blindness and imperfect eyesight : with a table of coloured Berlin wools and sheet of test-types / by Charles Roberts.

THE DETECTION OF COLOUR-BLINDNESS AND IMPERFECT EYESIGHT

ROBERTS

N.B.—This sheet of TEST-TYPES *must be kept Clean.*

No. 1—of the Life History Album.—(12 inches.)

37, 35, 60, 690, 950, 8034, 473, 533 3530, 4303. So Clive Newcome lay in a bed of down, and tossed and tumbled there. He went to fine dinners, and sat silent over them; rode fine horses, and black Care jumped up behind the moody horseman. He was cut off in a great measure from the friends of his youth, or saw them by a kind of stealth and sufferance: was a very lonely, poor fellow, I am afraid, now that people were testimonialising his wife, and many an old comrade growling at his haughtiness and prosperity. Willingness, health, fortune,

In former days, when his good father recognized the difference which fate, and time, and temper, had set between him and his son, we have seen with what a gentle acquiescence the old man submitted to his inevitable fortune, and how humbly he bore that stroke of separation which afflicted the boy lightly enough, but caused the loving sire so much pain. Then there was no bitterness between them, in spite of the fatal division: but now, it seemed as if there was anger on Thomas Newcome's part, because, great, measure, house, country, paper, bell,

No. 2.—(24 inches.)

75, 56, 42, 70, 9042, 450, 637, 768, 426. though come together again, they were not united, though with every outward appliance of happiness Clive was not happy. What young man on earth could look for more? A sweet young wife, a handsome home, of which the only encumbrance was an old Father, who would give his last drop of blood in his son's behalf. And it was all to bring about this end that Thomas Newcome had toiled and had amassed a fortune!

N° 10. *(10 Feet.)*

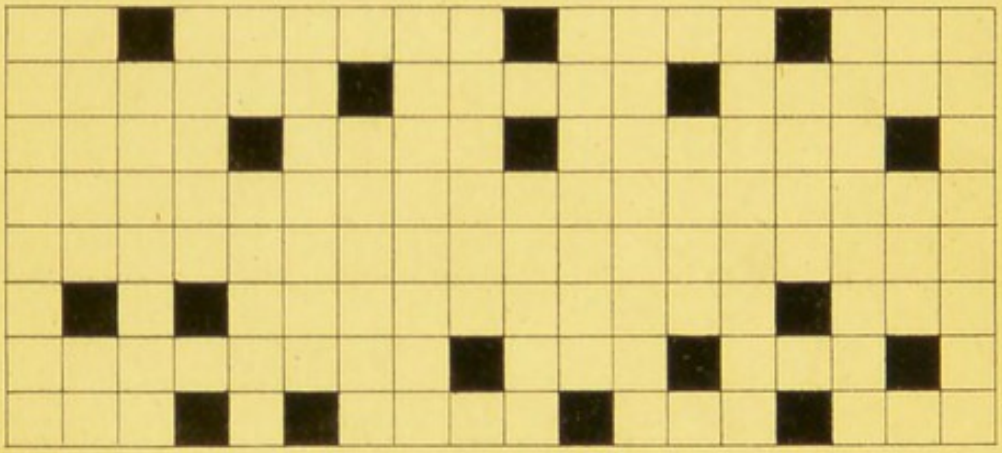
V Z B D P H K O S U Y

A X C N E P L G R T 10

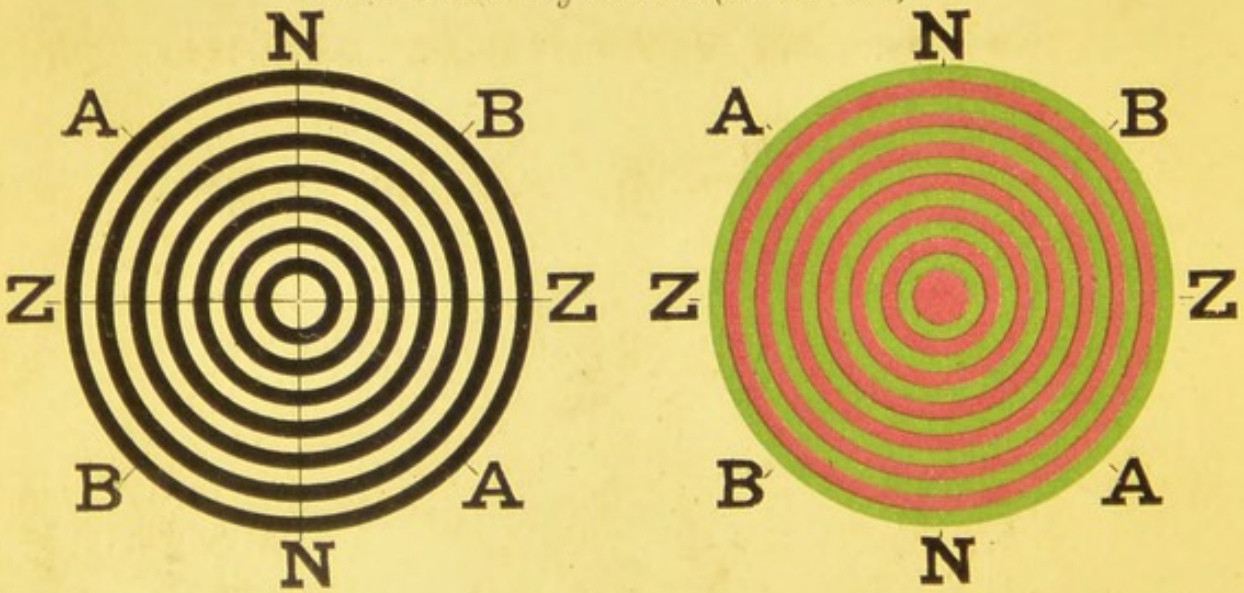
N° 15. *(15 Feet.) N° II of Life History Album.*

N P R T V Z B D

N° 57. *Army test dots. (57 Feet.)*



N° 20. *For Astigmatism. (10 - 20 Feet.)*



1918

C. J. Whitnell
October 1887

THE DETECTION

OF

COLOUR-BLINDNESS & IMPERFECT EYESIGHT

WITH A TABLE OF COLOURED BERLIN WOOLS

AND SHEET OF TEST-TYPES.

SECOND EDITION.

Originally arranged for the Anthropometric Committee of the British Association for the Advancement of Science,

By CHARLES ROBERTS, F.R.C.S., &c.,

LATE ASSISTANT SURGEON TO THE VICTORIA HOSPITAL FOR CHILDREN; AUTHOR OF A MANUAL OF ANTHROPOMETRY, ETC.

LONDON:

J. & A. CHURCHILL, 11, NEW BURLINGTON STREET.

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1884.

Colour Blindness, by B Joy
Jeffries, M.D., Boston 1879.

There have also been several
publications by foreign authors
who have discussed the subject
a good deal, chiefly as having
a bearing on the theory of
Colour Vision generally. Clerk Maxwell
& more lately Col. Abney have also
treated of it in the same way.

Most of the writers have
adhered to the Young-Helmholtz
hypothesis of three elementary
colour-sensations:- but for
my own part I much prefer
the system of Hering, of which
I wrote an abstract in "Nature"
for (Vols 20 & 21)
that seems to me to fit the facts
of my vision much more com-
pletely & satisfactorily than the
Helmholtz system, which I could
never willingly receive.

31, Parliament Street,
Westminster, S.W.

20 Oct 1887

Dear Sir I regret that your note of 12th has been so long unanswered but I have been away from home.

My description of my own case of Colour Blindness was published in the Phil. Trans. in 1859. There were some copies printed separately for sale, but I doubt whether they can now be bought.

I also wrote an Article called "Daltonism" in the Contemporary Review for May 1880, but no separate copies of that were printed.

Here are two books on the subject in English, — Wilson on Colour Blindness, Edinburgh 1855, — and

My "Philosophy of Music" is out of print in the first edition. The second edition is now printing, and ought to be ready immediately.

Very faithfully yours
William Pole.

Chas T. Whitmell Esq^r
H.M. Inspector of Schools
18 Park Place
Cardiff.

PREFACE.

—o—

This book of tests was originally prepared for the Anthropometric Committee of the British Association, for the purpose of collecting information relative to eyesight and colour-blindness by unskilled observers. The Committee having closed its operations, the book is now republished with some important alterations which practice has shown to be necessary or desirable; and it is hoped that it will, in its present form, be acceptable to Medical practitioners and Army and Ship Surgeons, as well as to parents and schoolmasters, for whom it was specially designed.

The test-types, No. 1 and No. 10, have been increased in quantity, as it has been found in testing school children that the sentences, and the order of the letters, are sometimes learnt by heart, and are repeated without being actually seen by the child under examination. Some of the intermediate types have been removed to admit of the introduction of No. 15, as that test-type has been adopted for the "Life History Album" of the Collective Investigation Committee of the British Medical Association.

The table of coloured wools, which in the first edition was a copy of Dr. Daae's table,* has been entirely reorganised, and is now arranged somewhat after Dr. Stilling's method, and at the same time it has been more closely assimilated to, and has therefore become a better "key" to, Prof. Holmgren's

* Die Farbenblindheit und deren Erkennung, nach Dr. A. Daae. Berlin, 1878.

method. All the test-colours are placed on the left of the table, at the beginning of each row of wools, which makes them easily found by the person who undertakes the examination; and strands, or threads, of the test-colours are worked in between each of the confusion-colours, thus bringing them into immediate apposition, as they would be if held in loose skeins in the hand by Holmgren's plan. The colours are arranged in rows, as if they were different shades of the test-colours as colour-blind persons see them; and the rows in which the same test-colour is used are placed together, in order to show more clearly the different confusion-colours which the test elicits from green- red- and violet-blind persons. The table of wools is useful, therefore, for teaching the examiner the principles on which the various methods of testing the colour-sense are based.

Practice shows that it is impossible to draw a line between colour-blindness and colour-ignorance; and the chief difficulties attending the examination of the colour-sense is the ignorance of colours and their ordinary names displayed by imperfectly educated persons, and the careless application by educated persons of the common names of colours, or the employment of what may be called draper's and dress-maker's names for shades which can be easily defined by compound words. To simplify this, and to make the wool-card available for teaching purposes, a row of wools is introduced showing the primary and secondary colours, and some of the compounds derived from them; and two rows, one of reds and one of greens, are also given to show the difference between the word "shade" and "colour." The first row consists of different colours; the second row of different shades of one colour. The entire value of the table of wools as a test for colour-blindness depends on this distinction being observed.

Having found that astigmatism is more easily detected by a series of concentric circles (portions of which must necessarily pass through all the meridians of the eye) than by the two letters of parallel lines employed in the first edition, two diagrams of this kind have been introduced, the same letters, however, being retained to distinguish the horizontal (N) and the vertical (Z) forms of the defect. The coloured diagram is introduced to show the effect of astigmatism on coloured objects, and as a more sensitive test than the one composed of black and white lines. The colours employed are the two complementary colours green and purple, which, when seen in apposition with good sight, are rendered more brilliant by contrast, but when mixed together by astigmatic sight are reduced to a grey (theoretically a white) colour. In using these tests it must be borne in mind that the lines at the top and bottom of the diagrams are horizontal, and those across the middle vertical, so that the direction across the diagrams in which the lines are most distinctly seen indicates the nature of the astigmatism, and not the portions of the circle which are obscure or invisible. This apparent departure from the rule of recording the kind of astigmatism is a great advantage in the examination of children, as they are better able to say in which direction the lines of the circle can be seen and counted, than to describe the portions which are obscured or invisible.*

* Thus if the lines or colours are more distinctly seen on the line Z Z there is horizonal astigmatism, because the portions of the concentric circles are obscure at N N, where their course is nearly horizontal when the book is held in its proper position. The vertical and oblique forms of astigmatism are also shown, and must be recorded in a similar manner.

INTRODUCTION.

Much unnecessary alarm has been caused in this country by the publication of observations made in Germany on the deteriorating influences of certain occupation, and especially of school and college life, on the eyesight of children and young persons. The statistics collected by the Anthropometric Committee, though not so numerous as could be wished, show that no such deterioration occurs in England, but, on the contrary, that between ages 10 and 40 years a slight improvement takes place,—a result which might be expected from the operation of the physiological law that the function of an organ increases with its use. As no English statistics of eyesight bearing on this subject have been published, the following will be acceptable.

Observations were made by means of the Army test-dots* on all classes of the population following town and country occupations. The test-dots were devised as a minimum test, but when used as a maximum test they are visible (theoretically) at a distance of 57 feet, and owing to this great range are not well adapted for testing the sight of persons living in towns, where large, well-lighted rooms, suitable for making the examinations, are difficult to find. Instead, therefore, of using the whole of the returns sent in, one thousand observations, which are known to have been taken under the proper conditions of space and illumination, are made use of, with the following results :—

* See the sheet of Test-types, No. 57, on the cover.

OBSERVATIONS MADE WITH THE ARMY TEST-DOTS ON 1000 MALES OF THE AGES FROM 15 TO 65 YEARS.

	Feet.	Feet.	Per cent
Theoretical distance at which the dots are distinguishable	57·0		
Mean or most frequent distance observed	57·5	+ 0·5	
Average distance of total number ,, ...	50·2	− 7·3	= 12·7
,, ,, at ages between 15 and 40 years observed	50·8	− 6·7	= 11·7
,, ,, ,, ,, 40 ,, 65 ,, ,, ..	46·7	− 10·8	= 18·8
,, ,, of total country population observed ..	51·9	− 5·6	= 9·7
,, ,, ,, town ,, ,, ..	50·0	− 7·5	= 13·0

The agreement between the calculated and the *mean* observed distance shows that the examinations were probably made under the proper conditions of space and light. The average shows a deficiency of eyesight, which, when distributed over the whole number of persons examined, reduces the distance to 50·2 feet or 7·3 feet (12·7 per cent.) below the normal standard. The deficiency below the age of 40 years is 6·7 feet (11·7 per cent.), and above that age 10·8 feet (18·8 per cent.), showing that it is largely due to the natural degeneracy of the sight from advancing age. The average sight of the country population is a little better than that of towns, but this may be attributable in some measure to the more favourable conditions under which the examinations were made: the difference is about 2 feet in favour of country folks. It is difficult to draw the line between good and imperfect eyesight, but considerable practice with the Army test-dots shows that a person who can distinguish them at a distance of 30 feet (or half their theoretical distance) has good sight, and all below it may be said to have imperfect sight. Up to 30 feet 10·8 per cent. of the persons examined failed to distinguish the test-dots, and at 15 feet, the distance fixed by the Army regulations for the exclusion of recruits for imperfect eyesight, barely 1 per cent. failed to distinguish the test-dots. 19·3 per cent. failed to distinguish the test-dots up to 35 feet, and 26·5 per cent. up to 40 feet.

To ascertain the influence of school-life on the eyesight of boys, a series of observations, made with the test-types,

No. 1 and No. 10 of this book, by the Rev. T. A. Preston, at Marlborough College, have been examined with the following results. The statistics are valuable, as having been obtained under exactly similar conditions, and made on boys who may be said to have had a hereditary, as well as a personal, experience of educational discipline.

EYESIGHT OF 1146 BOYS AND MASTERS AT MARLBOROUGH COLLEGE.

	Boys.				*Masters.*	
Age last birthday .. .. years	11-12	13-14	15-16	17-19	20-40	40-60
Number of observations	183	521	315	93	19	5
Average of No. 1 test-type, inches	17·4	18·3	19·4	20·5	21·8	11·2
„ No. 10 test-type, feet	9·4	9·2	9·2	9·4	10·0	6·0

The *mean*, or most frequent, distance at which No. 1 was read was 19 inches, *i. e.*, 7 inches in excess of the theoretical distance of 12 inches; while No. 10 was read at the exact theoretical distance of 10 feet. The average distance at which the boys read the smaller type is 18·7 inches, a deficiency of 0·3 of an inch for the whole school; and the average distance at which the larger type was read was 9·3 feet, or a loss of 0·7 of a foot. The nineteen masters, between 20 and 40 years of age, read both types at a greater average distance than the boys. The average distance at which No. 1 was read increases at an almost uniform rate of 1 inch for every two years up to 18 years of age. The sight of the five masters, of the age of 40 and upwards, is probably exceptional, and the number of observations are too few to be relied on.

The following table is interesting as showing the relation which the two tests bear to each other when applied to the same individuals. The general disposition of the figures shows that the sight which is proved to be good by one test is good also by the other test; but there are some exceptions to this rule, a few of which are probably due to errors of observation. The table also shows the difficulty already referred to of

drawing the line between good and imperfect eyesight. Judging from the value of the groups of figures, I have separated the boys whose sight with No. 1 falls short of 12 inches, and with No. 10 of 7 feet, as possessing imperfect eyesight, forming 8·2 and 16·7 per cent. of the total number respectively. Thus 83·3 per cent. of the boys possess $\frac{7}{10}$ and upwards far sight, and 91·8 per cent. possess $\frac{12}{12}$ and upwards, normal near vision.

TABLE SHOWING THE RELATION OF THE NEAR AND DISTANT SIGHT OF MARLBOROUGH COLLEGE BOYS, AS TESTED BY No. 1 (12 IN.) AND No. 10 (10 FT.) TEST-TYPES.

Distance in inches at which Test-type, No. 1. was read.	Distance in feet at which No. 10 Test-type was read. ½	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total, No. 1 Test.	
Under 4 in.		1																		1	8·2 per cent. Imperfect near sight.
From 4 to 6	2	3	2																	7	
6— 8	1	7	3			1														12	
8—10		10	2	2		4		3	2	4										27	
10—12		13	1	1	3	3	5	1	7	1	6	1	3							45	
12—14		7	10	2	2	3	6	7	17	13	7	3	4	2	5	1				89	86·5 per cent. Good near sight.
14—16		3	11		5	2	8	18	7	25	18	7	6	4	1	2				117	
16—18			4	7	3	5	13	13	24	30	33	13	6	3	1	3				158	
18—20			2	3	4	4	6	16	31	43	39	26	23	11	2	3				213	
20—22				1	1	3	1	11	18	25	29	28	32	13	12	7	2			183	
22—24			1			5		1	7	15	24	24	19	9	10	8	2	1	1	127	
24—26								2	2	3	12	19	11	13	9	5	1			17	
26—28								1		1	4	8	7	4	3	1	5		1	33	5·3 per cent.
28—30										1	2	2	4	1	4	3		1		18	
30—32													1	1		2	1		1	6	
Total, Test, No. 10.	3	44	36	16	18	30	39	73	115	161	174	131	116	61	47	35	11	2	3	1115	
	16·7 per cent. Short sight.							74·5 per cent. Good far sight.							8·8 per cent. Long sight.						

Astigmatism..—Tested by the letters constructed of horizontal and vertical lines, 60·3 per cent. of the Marlborough College boys were found to be more or less astigmatic, 28·5 per cent. of the defect being horizontal, and 31·8 per cent. vertical, while 39·7 per cent. were entirely free from the defect. The following figures show that there is a disposition for astigmatism to increase with age :—

ASTIGMATISM OF 1124 BOYS AT MARLBOROUGH COLLEGE.

Age last birthday ..	11—12	13—14	15—16	17—19 years.
Number of observations	182	535	313	94
Normal sight	41·2	41·7	39·9	32·0 per cent.
Vertical astigmatism ..	32·0	30·0	31·9	38·3 ,,
Horizontal ,, ..	26·8	28·3	29·1	33·0 ,,

Colour-blindness.—The following statistics, collected by a Committee of the Ophthalmological Society, show that colour-blindness exists in this country in the same proportion as other European countries. Of 14,846 males examined 4·16 per cent., and of 489 females 0·4 per cent., were found to be colour-blind, the proportion between males and females being as ten to one. Colour-blindness appears to be largely associated with colour-ignorance in both sexes, and increases rapidly the lower we descend in the education scale; an exception, however, being found in Friends, among whom colour-blindness is more prevalent than among the general population, probably from hereditary causes.

Colour-blindness in Great Britain.

	Males.		Females.	
	No. obs.	Per cent.	No. obs.	Per cent.
General population	14,846	4·16	489	0·4
Professional classes, Marlborough and Eton	—	2·5	—	—
Middle-class schools	—	3·5	—	—
Police, our schools of same rank	—	3·7	—	—
Jews	949	4·9	730	3·1
Friends	491	5·9	216	5·5
Deaf and dumb children, poorer classes ..	145	13·7	122	2·4

In Ireland colour-blindness is more common than in England, and it is found to be twice as frequent among artisans as among the well-educated classes. The difference between red-blindness and green-blindness is not always obvious, but the proportion of the two kinds among males generally is as 2·0 of the former to 1·5 of the latter.

INSTRUCTIONS

FOR THE

DETECTION OF IMPERFECT EYESIGHT.

(*See the sheet of Test-types on the cover.*)

———o———

As a standard of vision we adopt clear and accurate perception, not uncertain recognition, of the test-types. Each eye should be examined separately.

To determine the acuteness of vision we measure the smallest angle at which objects of known size and known form are distinguished. To determine the visual angle we measure the extreme distance at which objects of definite size (*e. g.* letters) can be recognised; or we measure the size of the objects which can be distinguished when placed at a definite distance (*e. g.* one foot). Square letters, whose limbs have a width equal to one-fifth of the letter's height, are generally distinctly visible to a normal eye at an angle of five minutes (*i. e.* one-twelfth of a degree). The nearest point of distinct vision is from four to seven inches; the farthest point is infinite distance.

The numbers placed at the head of each set of types and diagrams express the distance in *feet* at which they can be seen by the normal eye (*i. e.* at an angle of five minutes).

Test I.—The test-types must be placed in the perpendicular position in good daylight, the light coming from behind or either side of the candidate. When the small test-types are used, the card should be held by the candidate at the farthest distance at which he can read or spell the letters with the greatest fluency. The distance between the card and the eye should be measured with a rule or measuring-tape.

Test II.—When the large test-types, test-dots, or diagrams composed of parallel lines are used, the card should be suspended on the wall, and a tape marked in feet laid on the ground. The candidate should be placed at a distance greater than that indicated by the numbers at the head of the type, and gradually advanced towards the card until he can clearly distinguish each letter or dot. His distance from the types will be shown by the tape at his feet.

Rule.—*The degree of acuteness of vision is found by dividing the distance at which the type is seen by the candidate, by the number at the head of the test-type* (i. e. *the distance at which it can be seen by the normal eye*). *Thus if No.* 10 *test-type is read at a distance of ten feet,* $\frac{10}{10} = 1$, *or normal vision; if at five feet)* $\frac{5}{10} = \frac{1}{2}$, *or one half that of normal vision. On the other hand, No.* 10 *may be distinguished at a greater distance than ten feet, say at twelve feet,* $\frac{12}{10} = 1\frac{1}{5}$. *In this case the vision is above the average.*

The test-dots (No. 57) are employed for testing the sight of recruits for the British army, and may be used when the candidate cannot read, or when he may have some motive for deceiving the examiner. Each test-dot is one-fifth of an inch square, and corresponds at a distance of fifteen feet with the bull's-eye of a target two feet square at six hundred yards distance. With perfectly acute vision these test-dots ought to be clearly visible in full daylight at nineteen yards. The following are the directions for using the test-dots in the British army:—"1. Measure off fifteen feet with precision. 2. Hold the card perfectly upright in front of the man, and let it face the light so as to be fully illuminated. 3. Expose some of the dots (not more than seven or eight at a time) by covering the remainder with a card, and desire the man to name their number and relative position. 4. Vary the groups frequently, to provide against deception, by using a covering card with a square portion cut out of one corner; six different groups of dots may be exposed without exceeding the number above mentioned." This is a *minimum* test, and is intended to ascertain if the candidate's eyesight is good enough for military service. As a test of acuteness of vision the farthest distance at which the dots can be distinguished with certainty, *out of doors*, must be ascertained.

When *astigmatism* exists horizontal and vertical lines (No. 20) cannot be seen with equal clearness at one and the same time, because the focal distance in the two meridian planes of the eye are unequal; the meridian of greatest curvature is most frequently vertical, while that of the least curvature is horizontal; sometimes they are oblique, but they are always at right angles to each other. Astigmatism is often associated with other forms of imperfect eyesight.

Diagnosis 1.—If the test-types can be read with fluency at the distances indicated by their respective numbers, and if the circular lines (No. 20) are seen with equal clearness all round at a distance of from ten to twenty feet, *the eyesight is normal.*

2. If the test-types can only be read with fluency at distances less than their numbers indicate, there is *short-sight* (or myopia). This defect can be completely corrected by suitable *concave* lenses.

3.—If the large type can be read at the proper distance, and the small type only at distances greater than their respective numbers, or not at all, and the candidate's age is upwards of forty years, there is *far-sight* (presbyopia), or impaired vision of advancing age. This defect can be corrected by suitable *convex* lenses.

4.—If the circular lines (No. 20) appear quite clear and distinctly defined in outline in one direction, while they are obscure or invisible in another, there is *astigmatism.* This defect can be corrected by suitable *cylindrical* lenses.

5.—If the test types cannot be seen clearly at any distance without the aid of lenses, or when the small types are held very near the eye and the large types quickly become obscure, and when reading soon causes fatigue or redness of the eyes, there is *over-sight* (hypermetropia), which can be corrected by suitable *convex* lenses; *weak-sight* (amblyopia); or *feeble-sight* (asthenopia). *Squinting* (strabismus) is often associated with some of these forms of imperfect eyesight. Weak-sight and feeble-sight are due to disease, and cannot be distinguished from other kinds of imperfect eyesight by means of test-types alone.

N.B.—To record observations made on the eyesight, the number of the test-type must be placed at the bottom, and the distance at which it can be distinguished by the candidate must be placed above it in the form of a fraction: thus, if the greatest distance at which No. 10 can be read is nine feet, the entry should be $\frac{9}{10}$; if twelve feet, $\frac{12}{10}$; and so on. Astigmatism must be recorded as "horizontal," "vertical," or "oblique," or by one of the letters (N, Z, A or B) nearest to the part of the circles which is *most distinctly* seen.

THE DETECTION OF COLOUR-BLINDNESS BY THE TABLE OF COLOURED WOOLS.

(*See the table of Wools on the cover.*)

An explanation of the table of coloured wools is given on the page facing the table at the end of the book.

No decisive results can be obtained as to the efficacy of a person's colour-sense by asking him the *names* of colours. One person's perception of colours may be good, yet his power of expression may be defective; whereas another may be colour-blind, but practice may have taught him the names of colours. The table of coloured wools has been marked with numbers, so as to avoid the necessity both for the examiner and the candidate to designate the colours by their names, and it is only required that the person under examination should reply in the affirmative or in the negative to the examiner's questions. The wool patterns are already sorted, as they would be by colour-blind persons tested by Holmgren's method. The table contains ten horizontal lines, one of which contains samples of different *colours* (No. 1), and two are filled with one colour in various *shades* according to the degree of light (No. 2, red; and No. 8, green).

Test I.—The table should be placed in good daylight, and the candidate should be told that some of the horizontal lines contain colours of one description in different *shades*, and others different *colours;* after which, the first line should be pointed out, and the candidate questioned whether all the colours therein are of the same description, which question should be repeated with each consecutive line.

Diagnosis 1.—If the candidate designates the two uni-coloured lines (*i. e.* No. 2 and No. ~~10~~) correctly, and dismisses all the rest as mixed, his colour-sense may be considered *good.*

2.—But if he does not designate them correctly, nor any of the others, his colour-sense is *undecided.*

3.—If he designates one of the lines with various colours as being all of the same colour, he is *colour-blind,* and he will have great difficulty in distinguishing between *green* and *red.*

1 3 4 5 6 7 9 10

Test II.—It is always desirable to repeat the examination again and again if it has not proved satisfactory in the first instance, and to require in all cases that the single threads of the test-colours, which are worked in among the confusion colours, shall be recognised by the candidate. To qualify the result of an examination by Test I. a colour should be pointed out, and the candidate required to find all the similar colours on the table. Suppose *red*, the first sample of line 1, is pointed out, and the candidate is found able (although with some difficulty) to point out the other red pattern, he evidently shows a keener perception for red than if he were to associate it with grey, brown, or (as sometimes happens) with green colours.

The same method may be employed with other colours, but it should be remembered that, generally, light colours are more apt to engender mistakes than saturated tints. In doubtful cases it would be well to continue this examination through all the colours in line 1.

The colour-sense is very differently developed in different individuals: while some are able to distinguish the minutest tints, others have great difficulty in doing so, and some seem to be able only to make a broad distinction between dark and light colours. The line drawn between an average sense of colour and colour-blindness must be deemed arbitrary. For ordinary purposes a person cannot be called colour-blind if he be unable to distinguish the various shades of red or the various shades of green, or between blues and violets with accuracy; and colour-blindness can only be said to exist if decidedly green, red, brown, or grey colours cannot be separated; also when decidedly blue, violet or purple colours are not with certainty distinguished from yellow or grey. Much of the confusion which exists with regard to colours, especially among males, is due to ignorance of their names and their relation to each other, and can be removed by a proper education of the colour-sense. This education should form a part of the ordinary training of all school children.

THE DETECTION OF COLOUR-BLINDNESS BY HOLMGREN'S METHOD WITH LOOSE SKEINS OF BERLIN WOOLS.*

A selection of Berlin wools in small skeins is made, including red, orange, yellow, yellow-green, pure green, blue-green, blue, violet, purple, pink, brown, grey,—several shades of each colour, and at least five gradations of each tint, from the deepest to the lightest. Green and grey, several kinds each of pink, blue, and violet, and the pale grey shades of brown, yellow, red, and pink, must especially be well represented.† To determine whether the colour-sense is or is not defective, a light green has been selected (see table, line 3),—dark green may be also used,—because green, according to the Young-Helmholtz theory, is the whitest of the colours of the spectrum, and consequently is most easily confused with grey. For the diagnosis of the special kinds of partial colour-blindness, purple (*magenta*) has been selected; that is the whole group of colours in which red and violet (orange and blue) are combined in nearly equal proportions that no one sufficiently predominates over the others to the normal sense, so as to give its name to the combination.... The sample colours, therefore, are the two complementary colours of each other,—*green* and *purple* (see the first sample on lines 3, 4, 5, 6 and 7 of the table of wools).

Method of Examination and Diagnosis.—The Berlin wools are placed in a pile on a table in broad daylight. A skein of the test-colour is laid aside, and the candidate is requested to select the other skeins most resembling it in colour and place them by the side of the sample. It is necessary that the candidate should understand what is required of him. The examiner should explain that resemblance in every respect is not necessary; that there are no two specimens exactly alike; that the only question is the resemblance of the *colour*, and that, consequently, he must endeavour to find something similar of the same shade, something lighter and darker of the same colour. The mode of procedure may be explained practically to a large number of persons at the same time without loss of security, for no one with defective colour-sense finds the

* Condensed from Dr. Joy Jeffries's translation in 'Colour-blindness; its Dangers and Detection.' Boston, U.S.A., 1880.

† Sets of wools can be obtained of Messrs. Pickard & Curry, Opticians, 195, Great Portland Street, London, W.

correct skeins in the pile of wools the more easily from the fact of having a moment before seen others looking for and arranging them. Besides the "*test-colours*," which the examiner presents to the candidate, there are the "*colours of confusion*,"—that is to say, those which the colour-blind selects from the heap of wools, because he confuses them with the other samples.

Test I.—The green sample (the first sample in line 3) is presented. This sample should be the palest shade (the lightest) of very pure green, which is neither yellow-green nor blue-green to the normal eye, but fairly intermediate between the two, or at least not verging upon yellow-green.

Rule.—The examination must be continued until the candidate has placed near the sample all the other skeins of the same colour, or else, with these, or separately, one or several skeins of the class corresponding to the "colours of confusion" (line 3), until he has sufficiently proved by his manner of doing it that he can easily and unerringly distinguish the confusion colours, or until he has given proof of his difficulty in performing this task.

Diagnosis.—He who places beside the sample one of the "colours of confusion" (line 3)—that is to say, finds that it resembles the "test-colour"—is *colour-blind*. He who, without being quite guilty of this confusion, evinces a manifest disposition to do so has a *feeble colour-sense*.

If we need determine only whether a person was colour-blind or not, no further test would be necessary. If we want to know the kind and degree of his colour-blindness, then we must go on with another test.

Test II.—A purple skein is shown to the candidate. The colour should be midway between the lightest and darkest (the first sample on lines 4, 5, 6 and 7).

Rule.—The trial must be continued until the candidate places near the sample all or the greater part of the skeins of the same colour, or else, simultaneously or separately, one or several skeins of "confusion" (lines 4, 5, 6 and 7). He who confuses the colours selects either the light or deep shades of blue and violet, especially the deep (lines 5 and 6); or the light or deep shades of one kind of green (blue-green) or grey, including the blue (line 4).

Diagnosis 1.—He who is colour-blind by TEST I. (line 3), and who, in TEST II., selects only purple skeins, is *incompletely colour-blind.*

2.—He who, in TEST II., selects with purple only blue and violet, or one of them (lines 5 and 6) is *completely red-blind.*

3.—He who, in TEST II., selects with purple only green (blue-green) and grey, or one of them (line 4), is *completely green-blind.*

Remark.—The red-blind never selects the colours taken by the green-blind, and *vice versâ*. Often the green-blind places a violet or blue skein beside the green, but only the brightest shades of these colours. This does not influence our diagnosis.

The examination may end with this test, and the diagnosis be considered as perfectly settled. It is not necessary, practically, to decide whether the colour-blindness is red or green. But to be more entirely convinced of the relations of complete colour-blindness with signal colours, and to convince railway *employés* and others who are not specialists, the examination may be completed by one more trial. The one we are going to mention is not necessary to the diagnosis, and only serves to corroborate the investigation.

TEST III.—The red skein (the first sample on lines 9 and 10) is presented to the candidate. It is necessary to have a vivid red colour, like the red flag used as signals on railways.

Rule.—The test, which is applied only to those completely colour-blind, should be continued until the candidate has placed beside the specimen all the shades belonging to this colour, or the greater part, or else, separately, one or several "colours of confusion" (lines 9 and 10). The red-blind then chooses, besides the red, green and brown shades, which to the normal sense seem darker than the red (line 9). On the other hand, the green-blind selects opposite shades, which appear lighter than the red (line 10).

Remark.—Every case of complete colour-blindness discovered does not always make the precise mistakes we have just mentioned in the preceding examinations. The exceptions are either instances of persons with an inferior degree of complete colour-blindness, or of colour-blind persons who have been exercised in the colours of signals, and who

endeavour not to be discovered: they, therefore, usually confound at least green and brown; but even this does not always happen.

Additional Note.—We have not given rules for discovering *total* colour-blindness, because we have not found any cases of this kind. If any such case should be found they will be recognised by confusion of every shade having the same intensity of light.

Violet blindness will be recognised by a genuine confusion of purple, red, and orange (line 7), in TEST II. The diagnosis should be made with discrimination. TEST I. often shows blue to be a "confusion colour;" this may, in certain cases, be the sign of violet-blindness; but not always. We have not thought it advisable to admit defects of this kind; only the most marked cases, that other examinations establish as violet-blindness, should be reckoned in our statistics. Finally, to acquire a desirable uniformity, it is necessary to add, that in the preparatory examinations, I record cases of *complete colour-blindness* by 2 (2 R, 2 G, 2 V), those of incomplete blindness by 1, and those of feeble colour-sense by 0·5 (0·5 R, 0·5 G, 0·5 V).*

* Om nagra nyare praktiska metoder att upptäcka färgblindheit. Prof. Holmgren. Upsala, 1878.

EXPLANATION OF THE TABLE OF COLOURED BERLIN WOOLS ON THE OPPOSITE PAGE.

N.B.—The test-colours are placed on the left of each row, and single threads are worked in among the confusion-colours.

Line 1 comprises the primary and secondary *colours;* their names are:— RED, Orange, *Yellow*, Yellow-green, GREEN, Blue-green, *Blue* (Ultramarine), VIOLET, *Purple*. With the addition of white and black in various proportions the whole of the tints on the card are derived from the colours whose names are printed in small capitals (primary or fundamental) and italics (secondary colours).

Line 2 comprises different *shades* of red running to yellow on the left hand, and to purple on the right.

Line 3 comprises the light green test and the confusion colours characterising *feeble colour-sense*, or *colour-blindness*.

Line 4 comprises the purple test and the confusion colours characterising *green-blindness*.

Line 5 comprises the purple test and the confusion colours characterising *red-blindness*.

Line 6 comprises the purple test of lighter shade and the lighter confusion colours characterising *red-blindness*.

Line 7 comprises the purple test and the confusion colours characterising *violet-blindness*.

Line 8 comprises different *shades* of green running to yellow on the left hand, and to blue on the right.

Line 9 comprises the bright red test and the confusion colours of *darker shades* than the test-colour characterising *red-blindness*.

Line 10 comprises the bright red test and the confusion colours of *lighter shades* than the test-colour characterising *green-blindness*.

Besides being of use for teaching the names of colours and their shades and various combinations, the table illustrates many of the properties of colours such as contrast, complementary colours, the influence of luminosity, and the combination of colours for decorative purposes. (See 'Modern Chromatics,' by O. N. Rood. *The International Scientific Series*, London, 1879.)

N.B.—As the wools are liable to fade the table should not be exposed unnecessarily to the light; and, as they are easily soiled, they must not be touched with the fingers.

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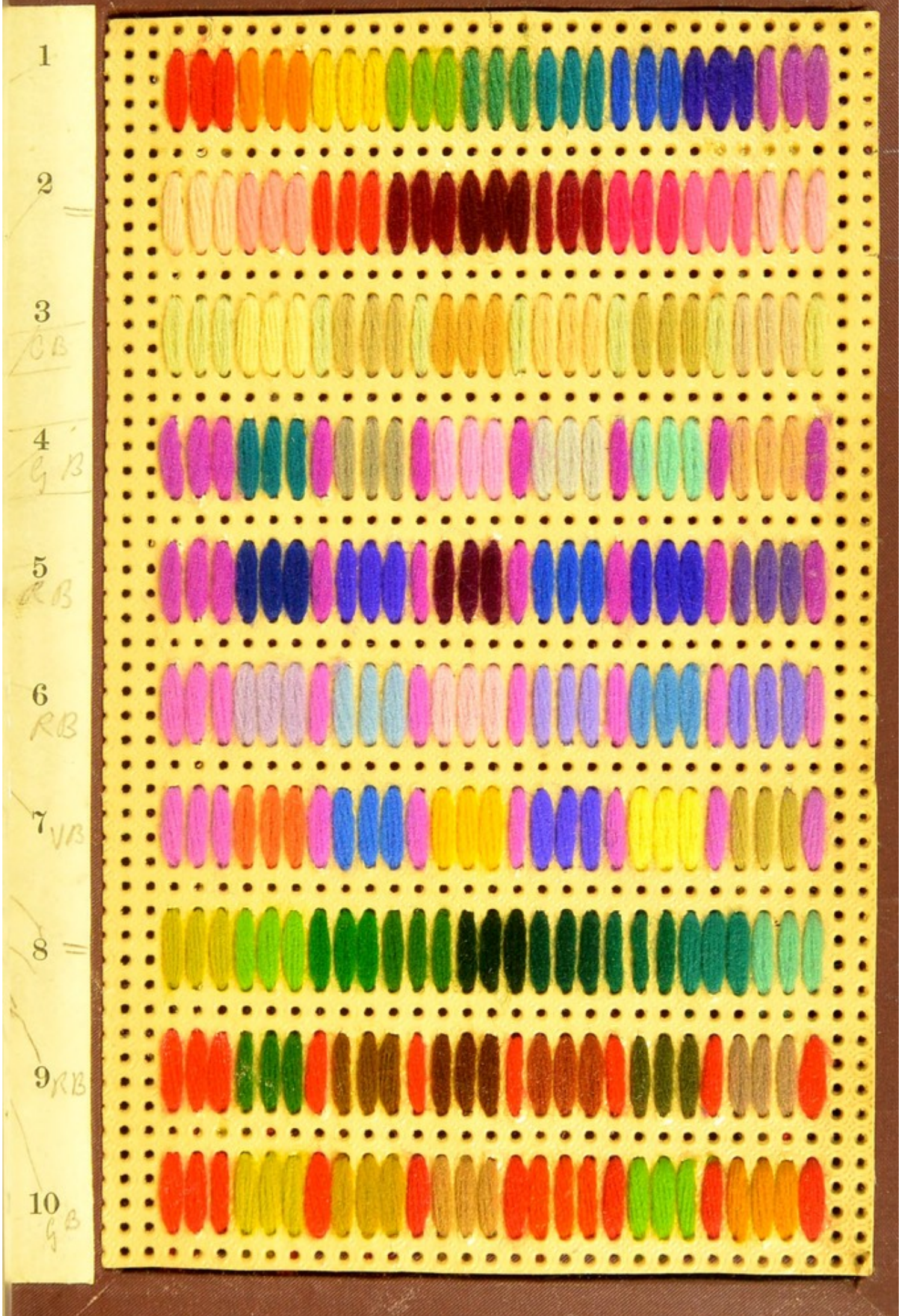
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