The Measurement of Visual Resemblance

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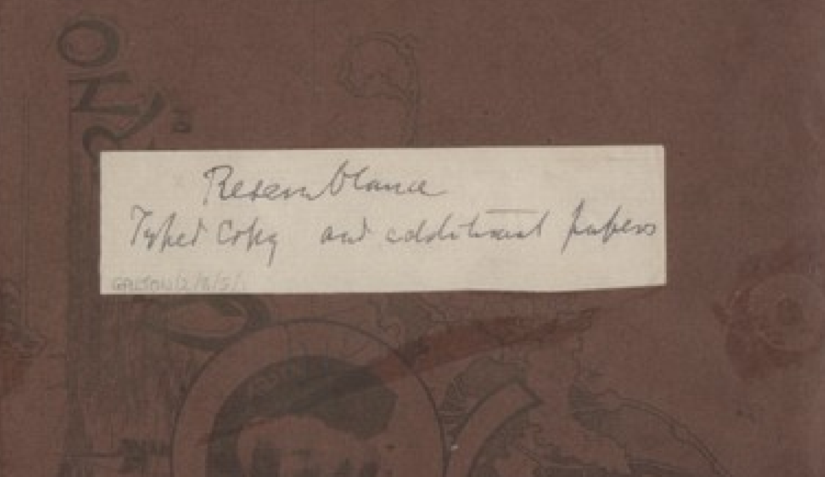
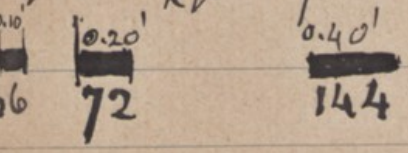
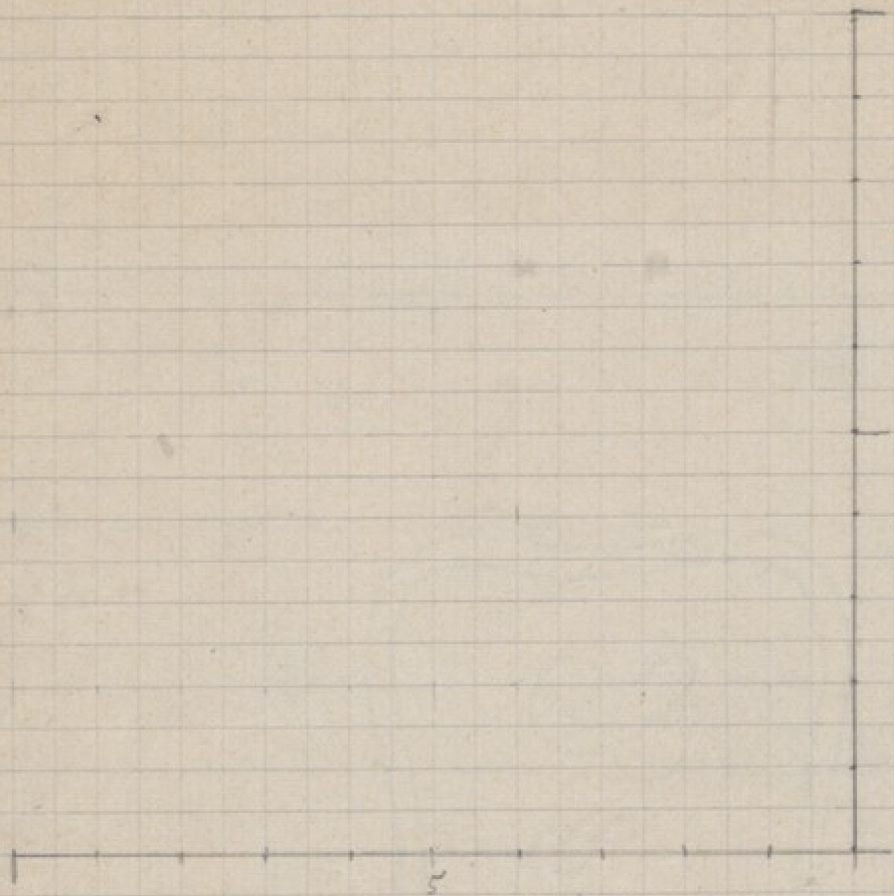


Resemblance
Typed Copy and additional papers

Below each test numeral draw a bar that shall subtend 10' at the distance in inches figured ~~clear~~ boldly below it (as here) 72 ~~at the side~~. Then when those letters are just legible the eye is at 72 inches from them and the length of the bar is ~~6~~ $\frac{72}{360}$ = 0.232 inch which is printed in ~~red~~ Snellen's Standard Numerals





Scale of deci-rads

Subtend θ	½θ	sin ½θ	Chord of θ $2\sin\frac{1}{2}\theta$	Decigrades	intervals	diffce	intervals in minutes
60°	30°	0500	10	10		6	
53.30	26°.45	450	9	9	6°.30		390
47.10	23.35	400	8	8	6.20	20	380
40.58	20.29	350	7	7	6.12	18	372
34.56	17.28	300	6	6	6.2	10	362
28.58	14.29	250	5	5	5.58	4	358
23.4	11.32	200	4	4	5.54	4	354
17.16	8.38	150	3	3	5.48	6	348
11.28	5.44	100	2	2	5.48	0	348
5.44	2.52	50	1	1	5.44	4	344

9) 556
62

		diffce	error
between 1 and 10 decirads mean 1 decirad varies between	390 & 344	46	13
358/400 (8.9) ½ to 5 decirads 5	358 & 344	14	$\frac{358}{100}$ $\frac{14}{x}$

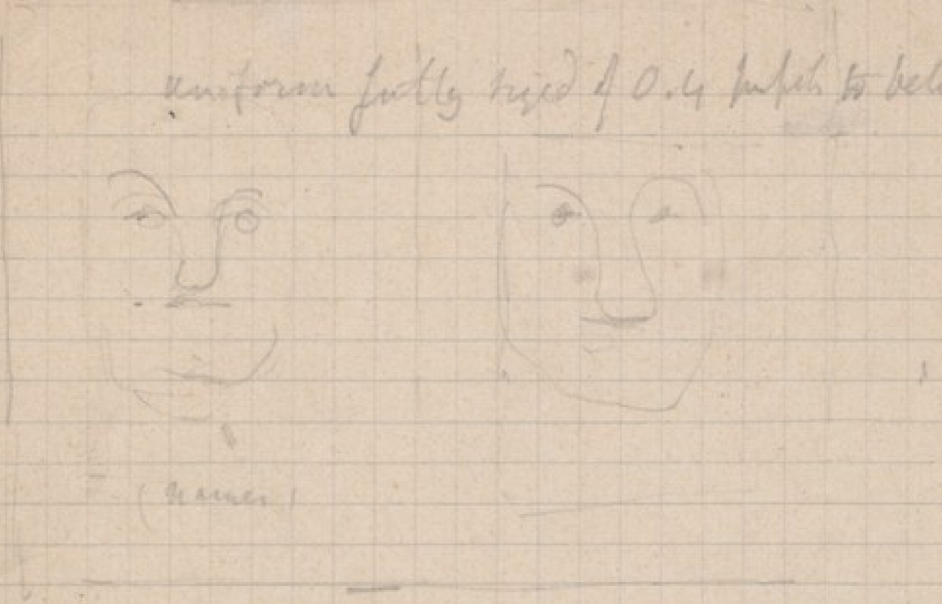
1074
3260

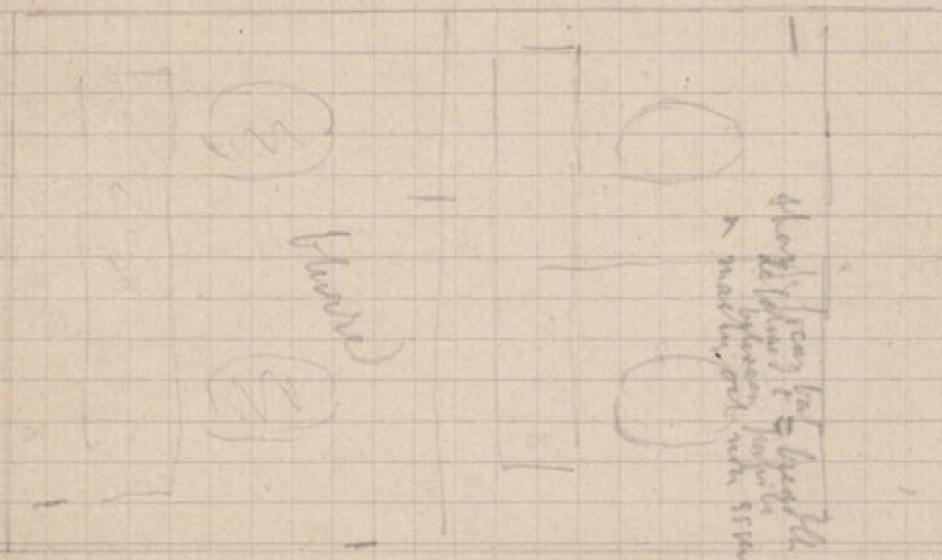
f. 2v

Radius = 10

Angle	Points	Sin	Tan	$2 \times \sin \frac{1}{2}\theta$
22° 30	one	3.827	4.142	
11 . 15	half	1.951	1.989	
5 . 38	quarter	0.982	0.987	

uniform partly tried of 0.4 pupils to between lips





{ ? blurr uniformly & estimate distance of just blur,
{ or blur to indistinguishability.

~~the~~ a larger type becomes illegible, also, ~~and so on~~ & so on. Familiar friends ~~[illegible]~~ ~~Known persons~~ are apt to be mistaken for one another, even at that distance ~~[illegible]~~, in the twilight. The effect of confused refraction is another cause of indistinguishability, as viewing objects through a piece of bad window glass, through an ill varnished piece of good glass, or through a mirage. I have often used ~~these~~ "confusers". ~~In any~~ to all of these cases the method of test-figures is applicable. The group-portrait I began by ~~obscuring~~ ~~is easily dealt with~~ by taking it away from the light, darkening the light still further ~~and~~ by shading it ~~further~~ with a book, or even with the hand.

~~After this outline of the process~~, ~~Some~~ A few points that ~~were~~ have been too briefly passed over ~~must~~ require now to be considered in more detail.

f. 5r

a

a'

b

b'

f. 8r

r = 1 Sin 10' = .0029

r = 2 " " = .0058

=

r = 1 sin 20' = .0058

2 = .0116 × 1/100 ... 1/100th of inch

= at 2 inches about 1/100 inch

r = 1 sin 30' = .0087

2 " 0.0174

.0105 = sin 36'

5 = 2'

.010 = Sin sin 34'

r = 1, sin 20' = .0058

2.5 25

.0290

.0116

.01350

1/4 at 25

0.25' at 25

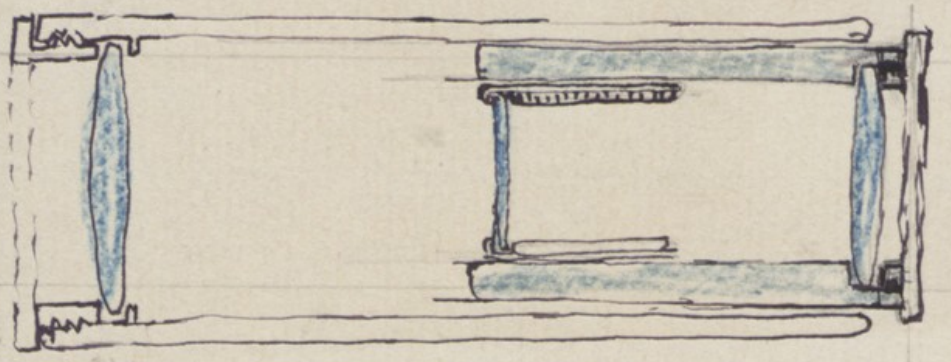
= .001 at 1

diam field of view = 1/6

= 0.166 = 3° 48' a good 3°

r = 50 mm

sin 30' = 0.435 mm



page, in the last case the height of the untailed letters 3, 5, or 8, as already mentioned. A very brief description suffices to specify the quality of the comparison in any of the above cases. (with approximate precision)

In judging resemblance the amazing powers ~~should be utilized~~ that the mind unconsciously exercises in ~~dwelling upon~~ the act of perception (can be utilized. The brain) ~~it~~ makes allowance (considerably) for differences of perspective, and it can dwell on one (portion of the) features to the practical exclusion of the rest. It is therefore better to judge whether the two portraits ~~may~~ refer to the same person, (rather than to judge) whether or no they are ~~|| distinguishable~~. In the first case ~~there~~ is little or no trouble is occasioned by differences of attitude, of costume, or of light & shade, in the latter cases these (non-essentials) may cause great difficulty.

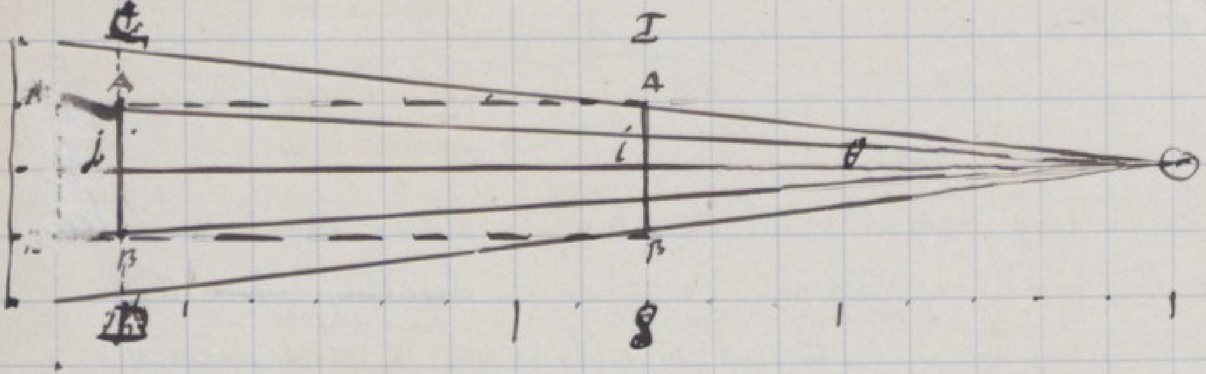
If there be no resemblance at all, as between two discs each painted half white and half black, ~~the~~ with the white half topmost in ~~the one~~ and the black half ~~topmost~~ in the other, ~~& must be such that~~ will have the value of about 1 minute of a degree, which is generally accepted as the angle subtended by the smallest visible object.

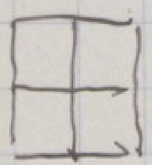
$d = [illegible]$ mm

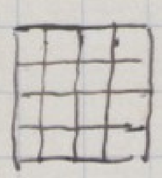
Imm is unit length   AB is any length on the portrait, say width of face

at II, 2 J.Vis lines to r   at I 4 J.Vis lines to r

then







$\frac{d}{CD} = \frac{i}{AB}$

AB = r mms = 2 J.Vis at II   α = 4 J Vis at I

$\frac{r}{2}$ = ratio per [illegible] at II $\frac{r}{4}$ = ratio per mm at I

ratio of $\frac{\text{one J vis at II}}{r}$

$\frac{1 \text{ mm}}{2 \text{ J.vis}}$ at II $\frac{1}{4 \text{ J.vis}}$ at I   linear

$\frac{1}{4}$ $\frac{1}{16}$ Sq

24

f 10r

(of suitable type)

The test card or cards are placed against or by the side of the pictures, in the same plane with them, and being perpendicular to the line of sight. On withdrawing from the pictures until they become just mistakeable the lines on the side toward which they converge will appear blurred while those on the other side are clearly distinguished; between these lies a point where just distinguishability begins. It will be noticed the interval between the top of any one line above that point & the top of the line below it will subtend an angle of one minute of a degree and 34.4 times that interval is the measure of the centric appropriate to the picture at the state of Just-Mistakability. ~~Lines of this~~ The figure suggests rather illustrates what is meant, more than one would be required for the production of a test card or cards suitable for practical use. It may be said that the [illegible] might replace the test lines, but it is not so easy as to [illegible]

Other ways of estimating resemblance:

Composite photographs — If a composite be measurable for either of its components the resemblance must be close. The method cannot be repeated by comparing the composite with one of its components, because that comprises no more than about three units of difference between the picture and the other.

Analytical photography, as I called it in a paper read some 3 years ago at the R. Photographic Society, may be of use in detecting differences. The negative of one is pressed face to face against the positive of the other and wherever the originals are identical the picture is a uniform grey. Elsewhere it is blacker or whiter according to which of the two prevails.

The remarkable effect should also be remarked mentioned of viewing nearly the stereoscopic pair two printed pages in one of which some slight alteration has been made, particularly as to the words. The altered letters become most conspicuous.

F. 11.5

A lead pencil 4 7 millimetres
or 0.28 inches in diameter is $\frac{1}{4}$

25 mm = 1 inch 1 m = $\frac{1}{25}$ inch

7 mm = $\frac{7}{25}$ inch = 25 | 7.0 (0.28
50
200

1 inch at 3450 miles
= $\frac{1}{4}$ inch at 862.5
30 $\frac{1}{3}$ inch at
$\frac{862.5}{30}$ miles

= 28.75 miles say 29 miles

25 |
140
56
700 millimetres = 0.7 metre
= 70 centimetres

f. 11 v

15 mm board

1 mm subtends 1' at 3440 mm distance

1530 mm — 30'

2 lead pencil at 1149

1 board pencil at 57.5 = 23 inches

25/575(23

50

75

2 tea pot stand

= 30 mm at 3450 = 1 sat at 345

= 1 at 113 25/113(4.5 mm

100

130

1 board pencil width at 9 inch = 1 sit

Lead pencil in 15 millimeter board

subtends 1' at 15 × 3450 mm

or 30' at $\frac{15}{310}$ × 3450 = 1725

25/1725(6.9 inches

150

225

25/15 d 0.6

1 board subtends 1' at 100 feet

inch — 30' at 3,3 feet

at 9.9 feet

box 10 feet

features. Sitting ~~N~~ unnoticed & sit on a seat in a fashionable promenade, I have dropped a stone & stick at various intervals distances from the seat, ~~say~~ as 15 20 & 25 yards, and observing people as they approach. ~~When people approach the seat for~~ ~~off~~ at 30 yards & further they can only be distinguished by the general form of the face & other very marked particulars. But as they come nearer a sense of what ~~is~~ abrupt change of emotion takes place is observed. It becomes possible & "real" the features, and attention is drawn & details that were previously non-apparent, ~~and~~ the value of

~~[Photographs.]~~ A set of test-figures are mounted side by side in parallel columns on a card ~~to be laid by the photographs~~ with the corresponding values of x boldly written below each. The test-card is laid by the portraits and when the areas under comparison become indistinguishable, the bold numeral below the ~~common~~ figures that do so at the same time, gives the measure of resemblance at once.

This method is of especial value when indistinguishability is due to other causes than distance under a clear light. The effect of increasing darkness is similar (that of increasing distance. Thus as the evening closes in, small type becomes illegible, shortly after

First as regards W. Two portraits may have more than one value of it according to the quality of the comparison, which may refer to the general appearance of the features in detail, or to some particular feature. When a person approaches and is still some [redacted] off, the general quality of the face (ignoring its form & size) is all we can recognise them by. In this case W is the diameter of the circle that includes the whole of his face. As he approaches more nearly it becomes possible rather suddenly, to read his general features, and a new value of W becomes necessary. On coming still nearer some particular feature may attract especial attention and a W may be wanted for that feature alone. Similarly as regards two tables of figures, as of logarithms. At some distance nothing more is apparent than columns of shading and the different pages are indistinguishable. Coming nearer, the columns are seen to be divided into paragraphs. Nearer still, the figures themselves are legible. In the first case W would refer to the width of the

f. 14v

A portrait group that lies beside me on the table will serve as a text. It is one of the sort that are commonly displayed in shop windows of towns, which are the seats of great public schools or universities. It consists of the full faces of [illegible] persons of both sexes, mostly of beardless athletic youths dressed in [illegible] costume, [illegible] under the same light, falling from the same direction, and consequently well suited for comparison. The nearer heads measure about 5 millimetres from chin to vertex, the more distant ones 4 or 3. Any one of the smaller faces can easily be raised to the same scale as one of the larger by holding a small magnifying glass over it at an appropriate height above it. The differences in scale will therefore be ignored. The problem is to measure the resemblance between any two of the portraits that are somewhat alike. I do not now speak of those that are wholly dissimilar, but shall do so later on.

~~The first step is to determine decide on a personal unit of measurement, which I commonly take as the distance in the portrait between the eyes drawn through the pupils and that through the pupils of the eyes.~~

at 1′ — with 1/2 mm grad & 5 × 1 intervals 350

In . Eyepiece 7 in long grad^d for 1′ = $\frac{1}{500}$ inch

for 5′ = $\frac{1}{50}$ in

In movie 1 mm = 40′

could easily graduate (1/4 mm) to 20′ · mesh = 100 cells

~~which on object~~

1 1/2 inch = 25 + 6 = 31 mm Eyepiece focus

31/3500(113

31 : 35 = 100 : 113

31 / 40 / 31 / 90

1 mm at 31 mm = 31 mm at 3500 = 1 at 113

= 1 to 11.3

10 mm

1 : 31 = x : 3500 = 1 t

Graduate in mms at distance 31 mm

1 mm at 35 mm subtends angle greater than 1 at 3500 in ratio 1/100 : 1

1 at 35 mm from Eye 1 mm subtends 100′

1 mm at 3500 mm subtends 1′, 1 mm at 35 mm subtends 100′

350 / 1 / 1

different degrees of obscurity at a given distance produces similar effects to different degrees of distance in clear light. One person is frequently mistaken for another in the gloaming and one letter from another. As the evening closes in two persons sitting side by side who resemble one another rather readily become indistinguishable, then those who are less alike, until a man cannot be distinguished from a woman. When quite dark nothing can be distinguished at all. So here the state of just Intelligibility occurs at any near distance under a certain dose of obscurity.

Just the same thing be said in respect to mist a fog, the intensity of which is commonly measured by the particular post in a row of them at equal intervals apart. The suddenness with which a person dressed in a London fog is always startling.

Similarly as regards confused refraction an object seen through a piece of faulty glass, or over a heated brick kiln, or through a telescope or on the ground glass of a camera when the lens is out of focus. A slight turn of the screw will then make letter print sharp & clearly legible that was blurred before.

The point that is wished to be enforced is that in every one of these conditions as state of just-intelligibility can be found with careful precaution

f. 17c

No. of just distinguishable differences under fixed conditions

1 Seen squarely
2 Same apparent size
3 Same surroundings
4 Same illumination
5 reduced to same scale of tints

analytical photo shews the difference. A & B are tint scale a & b half scale α & β such that A + B = b B + α = a

Can α and β be integrated? showing how much black there severally contain & similarly as to a & b? Then $\frac{a}{\beta}$ will be a mean

Each dome of squares with shot were also then you could get Σ(A − B) differences

1	3	2	=	6
3	1	3	=	7
+2	−2	+1		

= 5 if signs are disregarded
= +1 if " " regarded

but this is the maximum diff. that has to be considered (or accepted)

A	0	10	7	3	5	=	25
B	1	5	3	4	10	=	23
A − B	−1	+5	+4	−1	−5		

− 7
+ 9 +2

2 have to be added to B
and 16 have to be displaced

to change A into $5 + \frac{B}{2}$

$\frac{1}{2}A + \frac{1}{2}(10 - A) + \frac{1}{2}B = 5 + \frac{B}{2}$

faint neg A, all pos, faint neg B, 5 + faint pos B

Make A & B with same allowance of dots

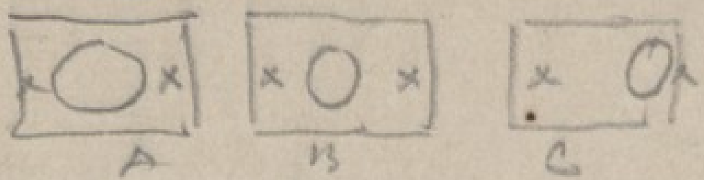
							No. of Dots	
A	0	6	4	1	9	=	20	
B	10	3	1	4	2	=	20	
A − B	−10	+3	+3	−3	+7			

average displacement per compartment $\frac{26}{5} = 5.2$

−13
+13
26

= 26 displacements distributed along 5 compartments

For tints, certain the number of just perceptible differences. f. 17v



by "mean change" principle B & C are equally like to A by J.P.D. system it is very different

To move from one corner to the opposite $n \times$ (P.D.) requires n intervals

If the diff: of tint be r(T) it w.d require r

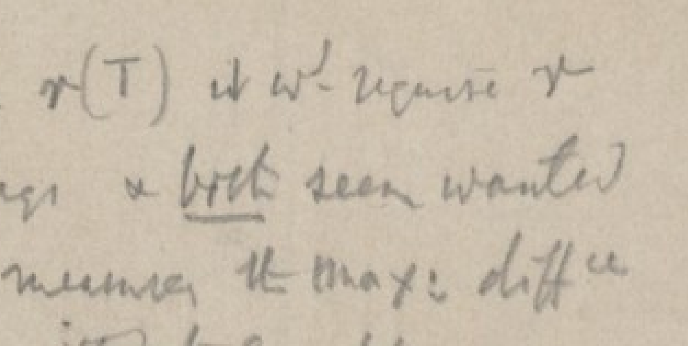
They are independent ways & both seem wanted

The smaller of the two measures the max: diffce

Also one may be permitted to except. as except for that patch the diffce are so & so, with 1/500?

Use a paper with a ? hexagon cut out & six adjacent hexagons of as many different tints

or a circle with many, a slide to cover all but the one wanted.



Position first, | tint after
estimated best |

f. 18r

Two portraits may be recognised as resembling each other in their traits, but while ~~they~~ differing so much in their broader features that no blurring will make them alike ~~indistinguishable~~ so long as they can be seen at all. By one rule ~~In the one case~~ they ~~are~~ judged alike by another ~~in the second~~ utterly dissimilar unlike. But If the cause of their unlikeness be their hair or other non essential, it may be mentioned, & then eliminated from further consideration. If it be in difference of proportion such as change of perspective could remove in a portrait that also can be mentioned & then disregarded. Subject ~~thus~~ to these provisos the general principle will stand ~~may be accepted~~.

f 18v

ege of 2 points

A blur of 10 fold the amount obliterates an interval of 10 times these amount in the portrait. or an angular value of about 35' with most that is admissible called fi 2 inches wide

The moon is less than 35' in diameter

twilight, tinted glass, half shut eyes.
fog, mist, muslin screen,
~~Rain on window, tears,~~
Bankshire mirage wavy glass, split objectglass, ground glass out of focus circle of confusion defective curvature of the lens
whirligig – zoetrope
brief view (Cattell),
Surroundings, light & shade & colour.
Errors of perception, fine faces, closed d°. traits (ignoring root) Gesture does not come in, except handwriting (digressive)
power of judgment to correct perspective – square table seen as rhomboid

deformation, perspective
size

Comparison of handwriting – similarity of 2 successive signatures without identity. ? process of experts in handwriting

Comparison of parts, each to each severally. is partial conformity, each letter in the word.
Traits, leading on from part to part, by curves of like kind, that is wh. in perspective convertible within a J.P.D.

Viewing pictures – movement (travel) of eye not equally free in all directions, rougher in some like a pantograph.

Pleasure of since in following intricate pattern
Hunting to find things – travel of the eye – most appropriate focus for the purpose is not very sharp. The habit of much reading
Select plan to throw a net & examine each mesh in succession.

Noticeable peculiarities – caricature, "charge". (a wealth of philosophy hidden in language)

Resemblance in sounds

The "only just perceptible difference" J.P.D

F.20

Statistical method by votes. A photographer made six admirable photographs of me, & I sent the resultant prints of selected poses. I numbered them A, B, C, D, E, F on their backs & took them about 30 friends in all, asking them severally & independently to sort them in the order of what they considered to be their likenesses to myself, disregarding ~~[illegible]~~ all other points. As might have been expected there was considerable disagreement in detail with a prevalent consensus. The choice of nearly all agreed in assigning the first place to one or other of two of them and it was ~~of course~~ easy to ~~classify them~~ determine the portraits that ranked on the whole as the first & as the second. But it was not possible without making some assumptions

2

2 to classify the remainder. It did not seem ~~How for example is it~~ possible to

2 8 9 mark them. Suppose ~~them to have~~ been placed ~~[illegible] respectively~~ by ten

4 5 ~~as second, 2 times as third once as fourth~~. Suppose the number of

30 votes for the successive places from first to sixth to have been in one case 1, 4, 8, 3, 10, 4 and in the other 2, 2, 9, 8, 4, 5 which should be ranked as the better? I have ~~once~~ discussed the relative value of a first & second place in Biometrika & shown that if prize money to the value of £100 is still has to be awarded in ~~first & second~~ between them, the proportional ~~[illegible]~~ [illegible] at given to the first & to the second, but ~~I see no~~ it does not seem possible to go much further than this with any assurance. Therefore I gave over the problem of measuring resemblance by votes as beyond my powers of solution and which ~~moreover~~, even if solved it would be a difficult to utilise of

f. 21r 8

I have made) ~~accustomed~~ (on this subject at different times during the last 2 or 3
~~After~~ various experiments ~~extending at intervals over two~~ years
~~the problem was best divided into two, & has recently been~~
considered anew. and I should be glad to explain ~~It seems best to compare this description~~
with the principal results, because the subject is ~~far too~~ very large) to be treated
~~in its entirety in a brief memoir~~ (& I doubt whether I shall have
time & strength to treat it ~~fully~~ hereafter as fully as it deserves.

Suppose we have before us, ~~one of those~~ group portraits of persons by my side, as I write, an ordinary group portrait
of the kind familiar ~~to young~~ (athletes or schoolmen or societies of) youths similarly placed & lighted in which light [illegible] appears to the
mostly beardless & dressed alike &c. In ~~the~~ one that I have by me
while writing this, the ~~size~~ length of head from chin to vertex of
persons in the foreground is about 5 mm, & of those in the background ~~&c.~~ expressing
as as little as ~~not more than~~ 3 mm) & the small head is ~~made comparable~~ The difference of scale is easily corrected ~~by comparison~~ to the
size of a larger ~~one~~ to be proposed comparison, by holding a lens over it at a suitable height.
The problem is to measure the ~~amount~~ resemblance between any two of
the ~~faces~~ portraits that bear at least some ~~small~~ resemblance to one another.
The first step is to determine the areas of the 2 portraits that are in the larger 1
to be compared, ~~such as would fall~~ whatever [illegible] within a circular such as might be confined
frame of W in diameter. This frame would necessarily ~~cannot~~ include more than

f. 21v

only some portion of it, it may be desirable to exclude the hair on account of some peculiarity in any of them or the mouth and chin on account of the beard). Finally suppose the selected area of the larger portrait and the corresponding area of the smaller one as seen through the magnifying glass to be as [illegible] may be included in a circular frame having the diameter D. It is the resemblance between these selected areas that it is proposed to measure.

When portraits, or persons are viewed at increasing distances the distinction between them decreases, and if they are at all they become indistinguishable at a moderate distance. Such is the case with the areas of comparison. If they were wholly unlike, say the upper half of the one black & the lower half white, and conversely as regards the other, they would be distinguishable until so far removed that they seemed minute dots which would take place when the diameter of the area subtended an angle of about 1 minute of a degree, which is pretty closely that subtended by one inch at 100 yards. But as regards the smaller areas now in question the portraits cease to be distinguishable at they subtend much larger angles than 1 minute of a degree

Nearly full faces

	includes all beard & Extreme Height	Extreme width	pupils to mouth	Extreme Height = 100 Breadth		Pupil distance = 100 Height	
				Breadth	Pup. dist	Height	Breadth
1	42	30	11	72	26	38	27
2	42	35	14	84	33	30	25
3	45	30	12	67	27	37	25
4	45	30	14	67	31	32	21
5	50	35	13	70	26	38	27
6	60 great beard	40	13	67	22	46	31
7	42	35	13	84	31	32	27
8	50	35	14	70	28	36	25
9	55	40	17	73	31	34	25
10	46	37	17	80	37	29	23
	477		138	73.4	29.2		

138) 477 (3.465
414
630
552
880
828
620

Height of head, extreme : eye-mouth = 3.46 : 1
including beard

Scrutiny

A suitable opera glass – out of focus till distortion ceases, then read test card

I define resemblance as mutual mistakeability under ~~certain~~ specifiable conditions, such as a certain distance; blurring, as due to seeing them through an ill focussed ~~telescope~~ telescope; fog, or obscurity, and the measure of resemblance as the square of the number of just-perceptible square units (in the specified area) at the same time. The length of the side of a square unit is obtained by placing a card ruled with gratings of various degrees of fineness, by the side of P and Q, and observing in which of them the lines just cease to be visible when ~~the difference between~~ P & Q cease to be distinguishable; Δp is to be measured ~~by means of that grating~~ in terms of Δi.

Let i = the interval between any two lines of the grating

The value ~~$\Sigma \Delta p$~~ n = the number [illegible]

There is great need for a method of measuring resemblance (when inquiring 1.25
into matters of heredity), the familiar phrases of rather like, like, very
like, in some respects like, been far too vague. I hope to supply
this need to some extent in the following memoirs. So far as I can learn
the subject has never yet been attempted. (in scientific style).

Resemblance, (in general depends on) is made up of great many more separate items, far more than
are consciously noted, and it is necessary to define what is intended to be
compared. If two the features of two persons are to be compared the
dress, gesture, and even the disposition of the hair have to be disregarded;
Or, it may be, that only some part of the features are to be compared. Or again
the character of the likeness may have to be expressed. Two portraits
may be alike though the features of the one may be broader than those
of the other. It is therefore important to limit the question of resemblance
in many ways. During the greater part of this memoir, unless otherwise
mentioned, the portraits I shall mainly keep in view are those of groups of young
athletes, alike bearded, dressed alike, all seen in full face, at about the same distance
falling from the same side. ~~Also I shall consider that perspective~~
~~deformation of a portrait is~~

It is difficult to pick out the faces of friends in those group portraits
unless they are on a large scale. On a smaller scale the distinctions in features, that
catch the eye are mostly those of comparatively non essentials ~~in what is~~
~~Commonly considered resemblance~~, such as quantity and disposition of
the hair, ~~as the texture of face~~ which so far as it depends on the

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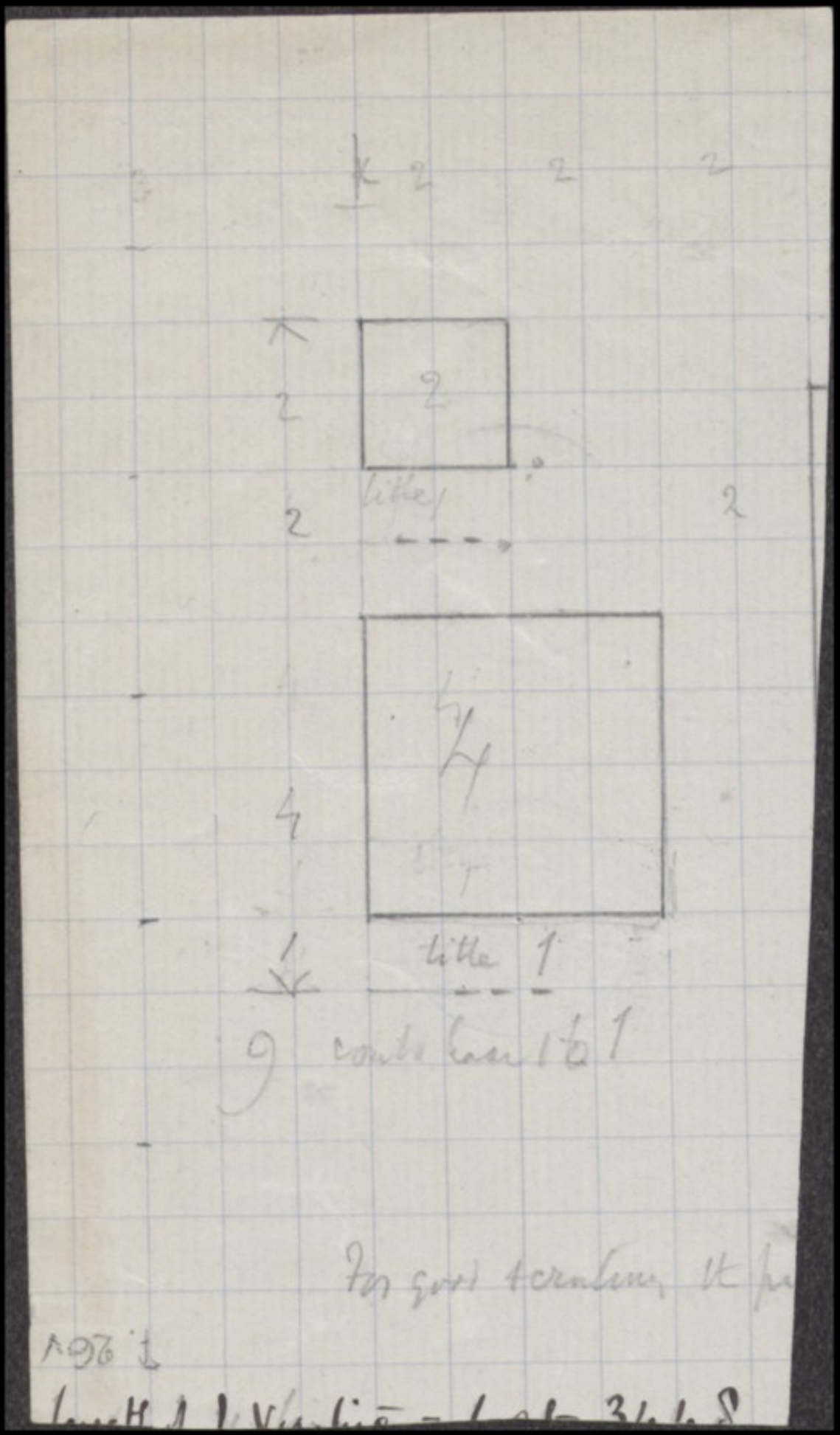
bigger
1 strip now occupies $12\frac{1}{2}$ mm
Each bar) $6\frac{1}{2}$
if 1 strip is to occupy 1 mm reduction to be from 1 to $12\frac{1}{2}$
1 strip

Reduction $\frac{1}{25}$ th or [illegible] $\frac{2}{25}$


2
2
2
2
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like
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like 1
9 contains 1 to 1

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THE MEASUREMENT OF VISUAL RESEMBLANCE.

by Francis Galton, FRS.

Carbon Copy.

F. Galton Feb 1906

THE MEASUREMENT OF VISUAL RESEMBLANCE.

It is proposed to show that the visual resemblance between any two objects may be measured in units whose value is strictly defined.

Resemblance is independent of actual magnitude and has therefore to be expressed in angular units. It is curious that no popular terms exist to express them in the language of any civilised country, for not only would they be useful but the diameter of the Sun, when paled by an intervening cloud affords an excellent and practically constant standard for rough measurements. It would often be well to indicate objects in a distant landscape by describing them as so many sun-breadths to the right or left of some conspicuous feature, or to speak of a mountain seen from a specified place as towering so many sun-breadths in height, or as bulking so many sun-discs in area. But as sun-breadths are not terms in popular use, and as they are not the best unit for the purposes of this memoir, I will employ another that is. The sun's diameter may be taken as subtending an angle of 31.0 minutes of a degree, I will employ for my unit the diameter of an imaginary mock-sun that subtends 34.4 minutes, and is therefore wider than that of the real sun in the proportion of 10 to 9. Its merit lies in the fact that the tangent as also the arc of 34.4 minutes differ insensibly from 0.01; in other words the angular unit is that which is subtended by 1 measure of any kind, at the distance of 100 measures of the same kind. I will call the arc subtended by this angle at any specified distance a "Sol". ~~It is more briefly expressed, the arc of 34.4 minutes of a degree.~~ The intervals between the

lines in Fig I are tenths of inches; if viewed at 10 inches (which is roughly the distance between the eye and a book when reading with the head on the hand, the elbow on the table, and the fore-arm upright) are "Sols", and the side of the entire figure which is one inch long, is 10 "Sols".

The portions of the objects to be compared and between which Resemblance is to be measured, must be strictly defined. Non-essentials may be either masked out or be simply ignored, but there must be no vagueness as to the limits of the portions selected for comparison. If the objects be portraits, the selected portion may be any specified part of the whole of it. It may be a single feature, it may be the face irrespectively of hair, and of beard if any, it may be the whole head, or it may be the entire person. But, whatever it may be it must be defined.

It will save tedious parentheses in the following remarks if one term "comparate" be used to express either of the pairs objects compared ~~under~~ subject to all the following restrictions. The comparate is limited to the portion under comparison, the two comparates are supposed to be reduced to similar scales*, to be mounted side by side on the same movable screen, squarely to the line of sight, and to be viewed in good light ~~in~~ through a perfectly transparent atmosphere.

The screen with the portraits upon it, will have to be moved and studied at various distances from the eye, so it is essential to the right conduct of the experiments that the experimenter should either have the power of adapting the focus

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* I do not enter into details of ~~how~~ the way in which the portraits may be reduced to the same apparent size, by viewing them at different distances. There are difficulties about focussing them sharply at the same time, which it will be seen can be removed, and about ~~their being kept~~ making them at the same relative distance while being compared at various distances, which can be mechanically overcome.

of his eye, sharply, to the various distances, or that he should use an optical contrivance to supply the faculty in which he is deficient. The range of adaptability of my own eye, as in that of most elderly persons, has become very narrow, and during a long time was the cause of serious embarrassment in my various experiments on Resemblance. But all this difficulty was happily removed by the use of a small inverting telescope of very low power, that I made abroad in a very makeshift way, out of two small magnifying glasses that I had by me, with pasted paper tubes and corks. It acted so well that I was loath to replace it by a better. Its field of view was ample, and enabled me to focus my eye sharply on "comparates" at any distance from a few inches upwards. I will call telescopes that neither magnify nor minify, by the name of "Isoscopes", their use is simply to secure a sharp focus for the eye at any distance. Two convex lenses of 2 inches focal length, seem to be on the whole the most suitable for ~~ones~~ an isoscope.

The tubes must admit of a wide range of adjustment. Either lens may serve as the eyepiece; but when used as such, it should be covered by a cap with an eyehole. Distances must be measured from the object glass. An isoscope should be fitted with two eyepieces, one of them furnished with a micrometer of crossed lines. If the eyepiece be of 2 inches focus, and the distance between the lines one 50th of an inch, the intervals between them will subtend 1 sol and each small square will subtend one square-sol. Portraits viewed through an inverting telescope should be turned upside down; being reinverted thereby, they will appear erect.

As objects are removed further and further from the eye their details begin to disappear; the smaller ones first, then the next larger, and so on. The distance at which any specified detail is on the frontier between disappearing if moved further,

and (b) or of appearing if moved nearer, will be called the critical distance of that detail, and the angle which it then subtends is the critical angle. The critical distance is of course not a sharp line but a narrow borderland, whose width decreases as the eye becomes practised, and whose middle line is taken for the critical distance. The critical angle of Just-Distinguishability by a normal eye of any object, is usually estimated at one minute of a degree. [illegible] reduced to a mere point, in which all details vanish. Consequently as their critical angle, [illegible] however dissimilar when viewed more nearly, become apparently indistinguishable as to details.

The sharpness with which a critical distance can be determined is roughtly appreciated by holding a book printed in suitable type, squarely to the line of sight, and noting the critical distance of its legibility. Fig 2 and 3 afford better examples for trial. Fig. 2 consists of three main and vertical bands, surrounded by a black and white border. Each band is made up of strips, each strip is made up of unit squares in which black and white are equally disposed, usually in a quarterly arrangement of four subsquares. On viewing the diagram at about 6 feet distance, two sub-strips towards the right, will disappear; further off others will disappear in succession, until at a considerable distance the whole will produce the effect of one uniform blur. Fig. 3. is drawn for the same object. It consists of converging black and white sectors bounded by radial lines, of equal width at each vertical section. On walking backwards, a point will be reached at which the sectors begin to blur near the right hand margin, its vertical penumbra as it were, being fairly well defined. Walking still further backwards, the penumbra travels slowly towards the left. The vertical bar half-way is for the convenience of reference. It might be possible so to train the judgment that at the corresponding critical distance, all to the right of the vertical bar should be rated as blurred, and all to the left as distinguishable. It must be repeated that an isoscope will be wanted by the great majority of those who are likely to read this, to

enable them to perform the experiment properly.

Resemblance is rather a vague word, so the particular sense in which it is intended to be used ought to be defined. The process is of the same kind whether resemblance apply to that between a copy and to the recollection of the original from which the copy was made, or to a portrait and a recollection of the person to whom it refers, or to the resemblance between two comparates in which latter sense it will now be discussed.

The measure of Resemblance between two comparates is the number of Just-Distinguishable plots in them at the critical distance when the comparates as a whole are mutually mistakable, the possibility of mistaking one for the other being due to apparent identity in every one of the just-distinguishable plots. The more numerous the plots, the more minute is the coincidence, and consequently the closer the resemblance. The shape of the comparates is of no importance. Now each Sol contains the same number, namely (34.47)^2 of these minute plots. So a square Sol being a trustworthy, and convenient, unit of Resemblance, the number of them in either comparate at the critical distance of Just-Mistakeability is taken as the Index of Resemblance. The number of Sols is easily found by inserting the micrometer eye-piece and counting them.

For practical purposes the scale of resemblance may begin with one Sol = 1°; that is to say, if the comparates were so reduced as to fit into minute frames of one tenth of an inch in the side, and if when viewed at 10 inches distance they were mutually mistakeable, the resemblance would amount to at least 1°, but if mistakeability ceased on further enlargement short of occupying an area of two square Sols, the Index would be reckoned as 1°. Similarly for other cases. If comparates

framed in an inch border (as in the outer border of Fig. 1) were undistinguishable at 10 inches from the eye, they would count as at least 100° on the Scale of Resemblance.

A permanent record might presumably be obtained by photographing the comparates at the just-mistakeable distance, through a suitable telescope with a micrometer eye-piece divided into Sols. The photograph would be scored by the image of the sol lines, and if viewed at the distance at which the image of those lines corresponded with real sols, the photographs would reproduce what was seen at the time of the original observation.

Conclusion. -The measurement of Resemblance is of wider importance than may appear at first sight. It covers a field of research that escapes the ordinary measurements by foot rule, scales and watch. It is particularly applicable to a variety of biological studies in which hereditary likenesses and family or racial peculiarities are enquired into, and seems eminently suitable for comparing composite photographs. The account of the method I propose, has been given merely in outline. It presents many side issues of interest, and deserves a larger amount of photographic illustration than I am now able to give.

F. Galton

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