LETTERS TO THE EDITOR.

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Measurement of Resemblance.

At the distance of a few scores of paces the human face appears to be a uniform reddish blur, with no separate features. On a nearer approach specks begin to be seen, corresponding to the eyes and mouth. These gradually increase in distinctness, until at about thirty paces the features become so clear that a hitherto unknown person could thereafter be recognised with some assurance. There is no better opportunity of observing the effects of distance in confounding human faces than by watching soldiers at a review. Their dress is alike, their pose is the same, the light falls upon them from the same direction, and they are often immovable for a considerable time. It is then noticeable how some faces appear indistinguishable at distances where great diversity is apparent in others, and the rudely-defined idea will be justified that the distance at which two faces are just mistakable for one another might serve as a trustworthy basis for the measurement of resemblance. The same may be said of obscurity, of confused refractions, and of turbid media; but in this letter I shall confine myself almost wholly to the effects of distance under the conditions of ample light and a transparent atmosphere. Beyond this I shall say nothing, except in one paragraph almost at the end.

The scale of the features has, of course, to be taken into account. This is of much less importance in living persons than in portraits, because the differences in scale of the adult human face are not very great, whereas those in photographs and paintings—ranging as they do between miniatures and life-sized portraits—are so. It is necessary to adopt a *facial unit,* based on some specified dimension. That which I use is the vertical distance between the middle of the line that joins the pupils and the parting of the lips. It is unaffected by head-dress or by the thickness of the hair on the top of the head, while its lower termination can be located in a bearded face more accurately than the chin. I call this u. If the portraits have different units, they are distinguishable as u and u'. If d and d' be the critical distances at which mistakability first occurs, then u/d and u'/d' are necessarily equal, and either of them would serve as a measure of mistakability; but as u is very much smaller than d, this fraction would always be a decimal preceded by one or two zeros. Therefore I take the index of mistakability, which I will call N, as $=1000\,u/d$. It is, however, convenient to measure u and d by different scales; u in millimetres, distinguishing it as u_m; d in centimetres, distinguishing it as d_c. Then $N=100\,u_m/d_c$.

Of course, N could be expressed by the arc or angle of which u/d is the chord, but it would be a roundabout method, as angles could not be measured directly without special and troublesome apparatus. I find it very convenient for my purposes to employ a nomenclature for chords based on that of the metrical system, d, the distance, being the radius or "rad." So a chord $=1/100$ becomes a "centirad," and that $=1/1000$ a "millerad." A centirad is the chord of 34·4 minutes of a degree, and, therefore, a trifle larger than the apparent diameter of the sun or moon. It is equal to the apparent size of one-tenth of an inch at 10 inches distance from the eye, which is a convenient distance for reading small type. A millerad which subtends between three and four minutes of a degree, and is equivalent to 1/100 of an inch seen at 10 inches, is as small an interval as can usually be detected in photographs without scrutiny, though a normal eye is able to distinguish one-third or even one-fourth of that interval between sharply defined objects.

Mistakability is only an approximate measure of resemblance, for it depends more on the scale of the distinguishing features than on the amount of difference of those features. This peculiarity is well exemplified, though greatly exaggerated, by what is seen in the time-tables hung up by railway stations. From across the road, say, they all appear alike as a shade of uniform grey. On approaching nearer, differences are observed in the headlines; nearer still, varieties in paragraphing come into sight, and at a reading distance the figures are all simultaneously distinguishable. This experience is partly, but only partly, applicable to human faces. Those that are alike are certainly distinguishable at shorter distances than unlike ones, and I notice no excessive clustering of values closely round particular values of N in my results, which there would be if mistakability always occurred near a particular stage, such as that at which the whites of the eyes cease to be visible, or at twice or three times that distance.

A strong likeness in small details may so dominate the perception that a want of likeness in larger features is overlooked. Here the distance of maximum mistakability will be small, the portraits appearing more unlike when removed further off, and the small details cease to be visible. Extreme cases of partial likeness, whether in contour or in detail, would, of course, be noted and allowed for. With these exceptions the index of mistakability appears to be a fair, even, as I think, a close, approximation to an index of resemblance when the quality of the observed likeness is recorded by appropriate letters, as will be described later on.

The observational value of mistakability lies in its asking a simple question which different persons would answer in the same way, when they had become familiar with the method. On the other hand, *likeness* includes mutual *suggestibility*, a highly complex perception dependent on the mind of the observer, and consequently appreciated differently by different observers, as is notoriously the case.

The apparatus I now use with ordinary photographs acts very well, but I wasted much time before I contrived it, and more before sending it to be made in a workmanlike manner. I think it could still be improved, so I will describe, not my own, which was made for me by Baker, 240 High Holborn, but such as I should order if I required another one.

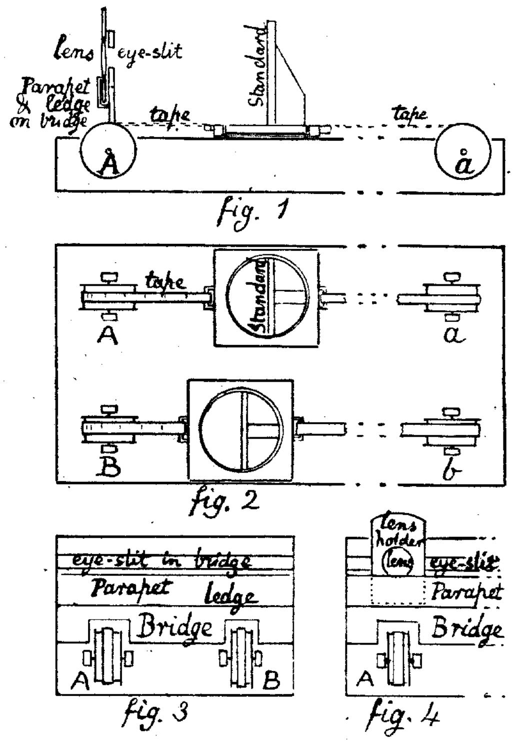
It is a long, thin, light box or framework $6\frac{1}{2}$ feet (2 metres) long, 10 inches (25 centimetres) wide, and 2 inches (5 centimetres) deep, which admits of being divided for sake of portability. It stands on two folding supports $2\frac{1}{2}$ feet apart, which fold back when out of use; when in use they can be clamped to any ordinary table. These raise the long box in a sloping position, the end towards the eye being at the most convenient height for a person seated on a chair, but the further end being lower, because it is easiest to look somewhat downwards. Two rollers, A and B (Figs. 1 and 2), run independently on a horizontal axis at one end of the box, and two corresponding ones, a and b (Fig. 2) at the other end. A light sledge that slides on the top of the box is harnessed in front to a tape graduated in centimetres, which passes over and round A, back to and around a, and thence forwards to the back of the sledge. (By inadvertence the path of the tape between the lower margins of A and a has been omitted in Fig. 1. The reader might dot it in pencil.) A similar sledge and tape is adapted to B and b. The tapes lie half an inch above the box (Fig. 1), and can be manipulated by the hands severally, so either or both sledges can be easily pulled either backwards or forwards while sitting in the chair, and their distances from the rollers at any moment be read off on the graduated tapes. (A winch and handle are superfluous.) The photos are mounted on two easily detachable standards (Figs. 1, 2), with clips at the bottom to hold them (not shown in the diagram), and standing on circular bases. These fit quite loosely into shallow hollows in the tops of the sledges. The standards can be lifted out, the photographs inserted, and the whole replaced with perfect ease. The circularity of the bases of the standards enables either of them to be set a little askew, which is convenient when the broad, full face of one portrait has to be compared with the narrowed, three-quarter face of another. A board stands vertically across A and B, and above them as a bridge. An eye-slit of half an inch width runs below its upper edge (Figs. 1, 3, 4), through which the photos are viewed, and from which the distances of the sledges are reckoned. A ledge 1 inch below the eye-slit (Fig. 1), with a parapet a little less than 1 inch high, forms a long, narrow groove into which light rectangular frames of wood, each with a spectacle lens in it, can be slipped and will stand upright (Figs. 1, 4). I chiefly use lenses of 12, 24, and 48 inches; my eye can accommodate its focus to intermediate distances, but I possess others which are sometimes serviceable. Younger persons with normal eyesight would want no lenses at all. The length of the box suffices for cabinet-size photos. An opera-glass reversed enables it to be used with larger ones, the minifying power of the opera-glasses at various short distances having been ascertained.

Mutual mistakability may occur under any one or more of the following conditions, which are to be noted, together with further remarks:—

a a. The portraits are apparently exact copies or reductions on different scales.

a. They appear to be portraits of the same person at about the same age, though differing in pose and dress.

b. They would be mistaken for portraits of the same person, even though they differ in sex and considerably in age, if the hair had been cut and dyed alike, and the dress arranged in the same way.



c. As above, if much disguised, as for theatrical personations.

b–c. Applies to cases intermediate between *b* and *c*.

P. Their resemblance is partial only, being confined to specified features.

The following little table saves trouble in operating; my own is more extended:—

Values of d_c in terms of N and of u_m $\left(d_c = \frac{100\,u_m}{N}\right)$

N	u_m 1	2	3	4	5	6	7	8	9	10
5	20	40	60	80	100	120	140	160	180	200
7·5	15	30	45	60	75	90	105	120	135	150
10	10	20	30	40	50	60	70	80	90	100
15	7	15	22	30	37	45	52	60	67	75
20	5	10	15	20	25	30	35	40	45	50
25	4	8	12	16	20	24	28	32	36	40

The procedure adopted after many trials was to measure the u_m of each portrait to the nearest half-millimetre and to write it below. Then to mount the two portraits, each on a separate sledge if their facial units differed, otherwise on the same. When they differed, the facial unit of the one about to be used for d_c was distinguished as u_m, the other was in brackets as (u'_m). Next, after referring to the above table, to send them to their respective d_c for $N=5$, to consider them carefully, and to note the result. Then to do the same for $N=10$, and so on, until the eye became familiarised with the differences between the portraits. Finally, guided by these provisional attempts, to fix on the suitable index and letter, adding such remarks as may seem wanted.

I became gradually more consistent in judgment, as ascertained by comparing the results on different days, but have felt all along that it would conduce to trustworthiness if two or more companions worked together and criticised one another, and recorded their common verdict.

A very brief example will suffice. Usually an entry consists of more lines followed by general remarks.

Two Sisters, Registers (so and so).
$u_m = 8·5$; $(u'_m = 9·0)$

N	d_c	Character of likeness
5 10	170 85	*b* Nearly *b*
After trials	115	Just *b*

Accept $N(b) = \frac{850}{115} = 7·4$

I will add a few words on dealing with mistakability caused through obscurity or other hindrances to clear vision. I prepared test cards, each containing numerals printed in different types, and, having ascertained by experiment the value of d_c for each kind of type when just able to read it in a clear light, wrote that value boldly by its side. An appropriate test card was put by the side of the portraits, and at the time when the portraits themselves were just mistakable, the written d_c of that row of figures which were just unreadable, was noted. The value of d_c remains constant whatever be the character or amount of the optical hindrance. If the hindrance increases, the portraits and the accompanying test card must be brought nearer to the eye. They will increase simultaneously in legibility. The written d_c will always show what the d_c would be in a clear light.

The applications of the process are numerous, as must always be the case when a hitherto vague perception is brought within the grip of numerical precision. To myself it has the especial interest of enabling the departure of individual features from a standard type to be expressed numerically. The departure may be from a composite of their race, or from a particular individual. The shortcomings of a pedigree animal from a highly distinguished ancestor could be measured in this way. Many other examples might be given.

I must not conclude without expressing gratitude for answers to a request, published by me some time ago in NATURE, for waste photographs from amateurs and professionals. If I be allowed to mention a single name, it would be that of Mr. Norman Campbell, whose photographs have been eminently serviceable.

FRANCIS GALTON.

Models of Atoms.

AN interesting and instructive variant of Prof. Mayer's experiment with floating magnets, which has been used so much to illustrate the structure of atoms, is to do away with the *centripetal* magnetic force and to arrange that its place be taken by forces arising from capillarity. This is managed as follows:—