Mr. R. W. FELKIN exhibited a Darfur boy brought to England by him in 1879, and made the following remarks:—

Suleiman Capsune, aged about eleven years, belongs to the Fur tribe of Central Africa. His birthplace was about 15 miles south-south-west of Dara. He was caught and made a slave when about six years old, his father and three brothers being killed in his defence. He is an intelligent sharp boy, and learns quickly, but has a tendency to spell and write backwards. This I think noteworthy, as his father had been taught to write and read Arabic. The Fur tribe is noted for being a warlike one, and, according to Arab statistics, numbers about one million. The cuts on the boy's face are not tattoo but slave marks. I have no further information about this tribe to offer to the Institute on this occasion, but have brought the boy here to-night as I may not have another opportunity of introducing him to the members.

Mr. FRANCIS GALTON exhibited an apparatus for testing the delicacy of the muscular sense, and read the following paper:—

On APPARATUS *for* TESTING *the delicacy of the* MUSCULAR *and other* SENSES *in different persons.* By FRANCIS GALTON, F.R.S.

I SUBMIT a simple apparatus that I have designed to measure the delicacy of the sensitivity of different persons, as shown by their skill in discriminating weights, identical in size, form, and colour, but different in specific gravity. Its interest lies in the accordance of the successive test-values with the successive graduations of a true scale of sensitivity, in the ease with which the tests are applied, and in the fact that the same principle can be made use of in testing the delicacy of smell and taste. I use test weights that would mount, in a series of "just perceptible differences," to an imaginary person of extreme delicacy of perception. The lowest weight is heavy enough to give a decided sense of weight to the hand when handling it, and the heaviest weight can be handled without any sense of fatigue. Their value being calculated according to Weber's law, they run in a geometric series—thus, WR^0, WR^1, WR^2, WR^3, &c.,—and they bear, as register marks, the values of the successive indices 0, 1, 2, 3, &c. It follows that if a person can just distinguish between any particular pair of weights, he can also just distinguish between any other pair of weights, whose register marks differ by the same amount. Example:—suppose A can just distinguish between the weights bearing the register marks 2 and 4, then it follows, from the construction of the apparatus, that he can just distinguish between those bearing the register marks 1 and 3, or 3 and 5, or 4 and 6, &c., the difference being 2 in each case. There can be but one interpretation of the phrase that the dulness of muscular sense in any person, B, is twice as great as in another person, A. It is that B is only capable of perceiving one grade of difference, where A can perceive two. We may of course state the same fact inversely, and say that the delicacy of muscular sense is twice as great in A as in B; similarly in all other cases of the kind. Conversely, if having known nothing previously about either A or B, we discover on trial that A can just distinguish between two weights, such as those bearing the register marks 5 and 7, and that B can just distinguish between another pair, say, bearing the register marks 2 and 4, then since the difference between the marks in the latter case is twice as great as in the former, we know that the dulness of the muscular sense of B is exactly twice that of A. Their relative dulness, or, if we prefer to speak in inverse terms, and say their relative sensitivity, is determined quite independently of the particular series of weights used in testing them. It will be noted that the conversion of results obtained by the use of one series of test weights into what would have been given by another series, is a piece of simple arithmetic, the fact ultimately obtained by any apparatus of this kind being the "just distinguishable" fraction of real weight. In my own apparatus, the unit of weight is 2 per cent., that is to say, the register mark 1 means 2 per cent.; but I interpolate weights in the earlier part of the scale that deal with half-units, that is, with differences of 1 per cent. In some other apparatus, the unit of weight might be 3 per cent., then three of my grades would be equal to two of the other, and my scale would be converted to the other scale by multiplying it by two-thirds. Thus the results obtained by different apparatus are strictly comparable.

A sufficient number of test weights must be used in the trials to eliminate the influence of chance. It might be thought that by using a series of only five weights, and requiring them to be sorted into their proper order by the sense of touch alone, the chance of accidental success would be too small to be worth consideration. It might be said that there are $5 \times 4 \times 3 \times 2$, or 120 different ways in which five weights can be arranged, and as only one is right it must be 120 to 1 against A. But this is manifold too high an estimate, because the 119 possible mistakes are by no means equally probable. When a person is tested, an approximate value for his grade of sensitivity is rapidly found, and the inquiry becomes narrowed to finding out whether he can surely pass a particular level. At this stage of the inquiry there is little fear of a gross mistake.

He is little likely to make a mistake of double the amount in question, and it is almost certain that he will not make a mistake of treble the amount. In other words, he would never be likely to put one of the test weights more than one step out of its proper place. If he had three weights to arrange in their consecutive order, 1, 2, 3, there would be $3 \times 2 = 6$ ways of arranging them. Of these he would be liable to the error of 1, 3, 2, and of 2, 1, 3, but he would hardly be liable to such gross errors as 2, 3, 1, or 3, 2, 1, or 3, 1, 2. Therefore, of the six permutations in which three weights may be arranged, three have to be dismissed from consideration, leaving three cases only to be dealt with, of which two are wrong and one is right. For the same reason there are only four reasonable chances of error in arranging four weights, and only six in arranging five weights, instead of the 119 that were originally supposed; these are—

1, 2, 3, 5, 4;	1, 3, 2, 4, 5;	1, 3, 2, 5, 4;
2, 1, 3, 4, 5;	2, 1, 3, 5, 4;	2, 1, 4, 3, 5.

But exception might be taken to two even of these, namely, those that appear in the third column, where 5 is found in juxtaposition with 2 in the first case, and 4 with 1 in the second. So great a difference between two adjacent weights would be almost sure to attract the notice of the person who was being tested, and make him dissatisfied with the arrangement. Considering all this, together with the convenience of carriage and manipulation, I prefer to use trays, each containing only three weights, the trials being made three or four times in succession. In each trial there are 3 possibilities, and only 1 success; therefore, in three trials, the probabilities against uniform success are as 27 to 1, and in four trials as 81 to 1.

Values of the Weights.

After preparatory trials, I adopted 1,000 grains as the value of W, and 1,020 as that of R. I made the weights by filling blank cartridges with shot, wool, and wads, so as to distribute the weight equally. I closed the cartridges with a wad, turning the edges over it with the instrument well known to sportsmen. On the wad by which each of them was closed, I wrote the corresponding value of the index of R, to serve as a register number. Thus, the cartridge whose weight was WR^4 was marked 4. The values were so selected that there should be as few varieties as possible. There are thirty weights in all, but only ten varieties, whose register numbers are respectively 0, 1, 2, 3, $3\frac{1}{2}$, $4\frac{1}{2}$, 5, 6, 7, 9, 12. The reason of this was to enable the weights to be interchanged whenever there became reason to suspect that the eye had begun to recognise the appearance of any one of them, and that the judgment might be influenced by that recognition, and cease to be wholly guided by the sense of weight. We are so accustomed to deal with concurrent impressions that it is exceedingly difficult, even with the best intention of good faith, to ignore the influence of any corroborative impression that may be present. It is therefore right to take precaution against this possible cause of inaccuracy. The most perfect way would be to drop the weights, each in a little bag or sheath of light material, so that the operator could not see the weights, while the ratio between the weights would not be sensibly changed by the additional weight of the bags.

Arrangement of the Weights.

The weights are placed in sets of threes, each set in a separate shallow tray, and the trays lie in two rows in a box. Each tray bears the register marks of each of the weights it contains. It is marked boldly with a Roman numeral, showing the difference between the register marks of the adjacent weights. This difference indicates the grade of sensitivity that the weights in the tray are designed to test. Thus, the tray containing the weights WR^0, WR^3, WR^6, is marked as in fig. 1, and that which contains WR^2, WR^7, WR^{12}, is marked as in fig. 2.

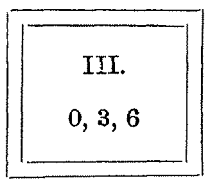

FIG. 1.

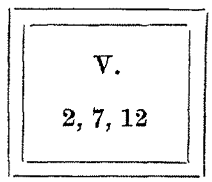

FIG. 2.

The Roman numerals in the following tables show the order of the arrangement of the trays in the box:—

Just perceptible ratio.	Grade of sensitivity.	Sequences of weights.	Just perceptible ratio.	Grade of sensitivity.	Sequences of weights.
1·020	I.	1, 2, 3	1·030	I½	2, 3½, 5
1·040	II.	3, 5, 7	1·050	II½	2, 4½, 7
1·061	III.	0, 3, 6	1·071	III½	0, 3½, 7
1·082	IV.	1, 5, 9	1·082	IV½	0, 4½, 9
1·104	V.	2, 5, 7	1·127	VI	0, 6, 12

The triplets they contain suffice for ordinary purposes, but it will be observed that sequences of a half can also be obtained, and, again, that it is easy to select doublets of weights for coarser tests in medical cases of deficient sensibility up to a maximum difference of XII.

Manipulation.

A tray is taken out, the three weights that it contains are shuffled by the operator, who then passes them on to the experimentee. The latter sits at ease, with his hand in an unconstrained position, and lifts the weights in turn between his finger and thumb, the finger pressing against the top, the thumb against the bottom of the cartridge. Guided by the sense of weight alone, he arranges them in the tray in what he conceives to be their proper sequence. He then returns the tray to the operator, who notes the result; the operator then re-shuffles the weights, and repeats the trial. It is necessary to begin with coarse preparatory tests, to accustom the operatee to the character of the work. After a minute or two the operator may begin to record results, and the testing may go on for several minutes, until the hand begins to tire, the judgment to be confused, and blunders to arise. Practice does not seem to increase the delicacy of perception after the first few trials so much as might be expected.

The tests show the sensitivity at the time they are made, and give an approximate measure of the discrimination with which the operatee habitually employs his senses. It does not measure his utmost capacity for discrimination, because the discriminative faculty admits of education. However, the requirements of everyday life educate all our faculties in some degree, and I have not found the performances with test weights to improve much after a little familiarity with their use.

I did not at first find it at all an easy matter to make test weights so much alike as to differ in no other appreciable respect than in their specific gravity, even though I used the machine-made cartridge cases. Two bodies may be alike in weight and outward appearance, and yet behave differently when otherwise mechanically tested, and consequently when they are handled. For example, take two eggs—one raw and the other hard-boiled—and spin them on the table; press the finger for a moment upon either of them, whilst it is still spinning. If it be the hard-boiled egg it will stop as dead as a stone; if it be the raw egg, after a little apparent hesitation, it will begin again to rotate. The motion of its shell had alone been stopped, the internal part was still rotating, and this compelled the shell to follow it. Owing to this cause, when we handle the two eggs the one feels "quick," and the other does not. Similarly with the cartridges, when one is rather more loosely packed than the others, the difference is perceived on handling them, and the knowledge so acquired vitiates future judgments in various indirect ways. A cartridge may have one end heavier than the other, or else its weight may not be equally distributed round its axis, so as to cause it to rest on the table with the same part always lowermost; and these differences also are easily perceived when handling them.

Again, two cartridges may balance perfectly in all directions, and yet their weight may be disposed too much towards the ends, as in a dumb-bell, or gathered too much towards the centre. The period of oscillation will differ widely in the two cases, as may be shown by suspending the cartridges by strings round their middles, so that they shall hang horizontally, and then, by a slight tap, making them twirl to and fro round the string as an axis. The touch is very keen in distinguishing all these peculiarities. I have mentioned them to show that experiments on sensitivity have to be made in the midst of pitfalls, warily to be avoided. Our apparently simplest perceptions are very complex; we hardly ever act on the information given by only one element of one sense, and our sensitivity in any desired direction cannot be rightly determined, except by carefully devised apparatus, judiciously used.[1]

The trials I have as yet made on the sensitivity of different persons confirm the reasonable expectation that it would, on the whole, be highest among the intellectually ablest. At first, owing to my confusing the quality of which I am speaking with that of nervous irritability, I fancied that women with delicate nerves who are distressed by noise, sunshine, &c., would have acute powers of discrimination. But this I found not to be the case. In morbidly sensitive persons, both pain and sensation are induced by lower *stimuli* than in the healthy, but the number of just perceptible grades of sensation between the two is not necessarily altered.

I found, as a rule, that men have more delicate powers of

[1] *Note by the Author, March*, 1883.—The sense of muscular effort may be isolated from the sense of touch by holding the test object in the extended hand, palm uppermost, while the back of the hand rests on the padded bars of a stirrup which is suspended from a string. The string passes over pulleys, and is attached to a weight sufficient to urge the stirrup upwards with the same force that the test object urges the hand downwards. At this moment no muscular effort is exerted to sustain the test object, but let the stirrup be suddenly depressed, and then, without any alteration of the sense of touch in the palm of the hand, a sudden sense of effort is called into existence to supply the loss of support. The fact of the soft and broad pressure having been removed from the back of the hand does not affect the judgment; it is so different in locality and in quality to the sense of effort that it is unobserved while the attention is fixed on the latter.

discrimination than women, and the business experience of life seems to confirm this view. The tuners of pianofortes are men, and so, I understand, are the tasters of tea and wine, the sorters of wool, and the like. These latter occupations are well-salaried, because it is of the first moment to the merchant that he should be rightly advised on the real value of what he is about to purchase or to sell. If the sensitivity of women were superior to that of men the self-interest of merchants would lead to their being always employed, but as the reverse is the case the opposite supposition is likely to be the true one.

Blind persons are reputed to have acquired, in compensation for the loss of their eyesight, an increased acuteness of their other senses. I was therefore curious to make some trials with my test apparatus, and I was permitted to do so on a number of boys at a large educational blind asylum, but found that, although they were anxious to do their best, their performances were by no means superior to those of other boys. It so happened that the blind lads who showed the most delicacy of touch, and won the little prizes I offered to excite emulation, barely reached the mediocrity of the sighted lads of the same ages whom I had previously tested. I have made not a few observations and inquiries, and find that the guidance of the blind depends mainly on the multitude of collateral indications to which they give much heed, and not in their superior sensitivity to any one of them. Those who see do not care for so many of these collateral indications, and habitually overlook and neglect several of them. I am convinced, also, that not a little of the popular belief concerning the sensitivity of the blind is due to occasional exaggerated statements that have not been experimentally verified.

Mr. GALTON hoped that the apparatus he had described might serve as a basis of discussion as to the instruments best adapted to form part of an anthropometric laboratory, intended to deal with the measurement of the various human faculties, so far as it was feasible to do so.

DISCUSSION.

Professor CROOM ROBERTSON did not feel competent, at that time, to enter upon the general subject of psychical measurements which Mr. Galton had proposed for discussion, but he had been greatly struck both by incidental remarks of psychological value in the paper, and by the ingenuity and care with which Mr. Galton had devised the apparatus of which special account was given. He wished more particularly to know whether, as the present apparatus was obviously adapted to the testing of "muscular sense" in its compound form, inclusive of touch, or skin-sensation, it had occurred to Mr. Galton to devise any means for measuring the muscular sense to the exclusion of touch. Though in practice we apprehend weight and other such qualities of matter through muscular organs, which were also tactile, it was not easy to distinguish the two elements of touch and muscular sense proper combined in any case. The difference of opinion prevailing among authorities as to the precise character of the nerve-process involved in our consciousness of the act of putting forth energy by way of muscle did not affect its independence as a real factor of experience. If the element of skin-sensation (passive pressure) could be eliminated by being rendered practically constant, muscular sense might then be tested in its purity. Perhaps Mr. Galton would say whether his attention had been directed to this aspect of the question.

Dr. Camps said that he wished to ascertain from the author of the admirable paper just read, Mr. Galton, if he was prepared to maintain his belief in the existence of more than five senses, and that mankind were endowed with a sixth sense which he had termed muscular sense. We had all been taught that mankind were endowed with but five senses, namely, those of sight, of hearing, of smell, of taste, and of touch. For his (Dr. Camps') own part, he was disposed to regard the so-called muscular sense, as only a modification of the sense of touch. Cutaneous or cuticular sensibility had been mentioned by a previous speaker, and on that subject he (Dr. Camps) said there existed a marked difference in different individuals, in regard to the development of the sensibility of the skin. Dr. Weber, whose name had been mentioned by the author of the paper, had invented an instrument—the *æsthesiometer*—by means of which the difference in regard to cutaneous or cuticular sensibility in different individuals could be measured or appreciated. Dr. Brown Sequard, now in Paris, so well known for his researches on the pathology and physiology of the nervous system, had given considerable attention to this subject, by the examination of a large number of persons.

Mr. Joseph Jacobs wished to know what arrangements had been made by Mr. Galton to determine the starting-point in his test weights, as this appeared to be 1,000 grains for all subjects. Now the logarithmic law, on which the whole investigation rested, only applies beyond a certain minimum of sensibility: it only applies "over the threshold," as the Germans say. But this threshold differs for each person, and to take the same threshold for all subjects was equivalent to taking one (logarithmic) curve for all, whereas each has a different curve with a differing constant. Unless, therefore, some means had been adopted to obviate this objection the whole method of the investigation would appear to be vitiated. It further seemed hazardous, under the present conditions of woman's social position, to judge the relative capacity for discrimination in the two sexes from the bare fact that women were not employed in some occupations. In one case known to the speaker, that of sorters of ivory for piano keys, the selectors were almost invariably women.

Mr. GALTON, in reply, admitted that the title of his paper was somewhat inappropriate; he had, in fact, intended to submit other apparatus as well, including a rather delicate instrument he had designed, but not yet made much use of, for determining the delicacy with which different degrees of pressure could be discriminated. By using this in connection with the test weights the influence of the sense of pressure might be got rid of, in the same way that an unknown quantity that enters into two equations can be eliminated. There were yet other instruments that he had intended at first to bring, but, thinking it would be difficult to exhibit them properly all at once, he had at the last moment refrained from bringing them. His apparatus on the table really professed to do no more than deal with the aggregate of the many sensations that concurred in enabling a person to discriminate between two different weights by handling them. Besides these different elements of sensation concerned in the process to which allusion had been made, there was another important one due to the inertia of the weights, as perceived by the pressure upon the thumb and finger while wagging the cartridges to and fro. The geometric series he had used was quite approximate enough when the initial weight is not too near to that which corresponds (in technical phraseology) to "the threshold" of sensation, and when the heaviest weight is not nearly heavy enough to excite fatigue. The numerical values of the middle terms of the scale of sensation come out much the same whether they have been calculated as a simple geometric series, or according to the more complicated formulæ of the investigators who have endeavoured to improve upon the earlier form of Weber's law.

NOVEMBER 28TH, 1882.

Lieut.-General PITT-RIVERS, F.R.S., *President, in the Chair.*

The Minutes of the last meeting were read and confirmed.

The following presents were announced, and thanks voted to the respective donors:—

FOR THE LIBRARY.

From Colonel ALMONTE.—Historia de la Geografía del Perú. Libro 1. By Antonio Raimondi.

——El Departamento de Ancachs y sus Riquezas Minerales. By A. Raimondi.

From the AUTHOR.—On the History of the Archaic Chinese Writing and Texts. By Terrien de Lacouperie, M.R.A.S.