

Brief Notes for consideration, by FRANCIS GALTON.

SKIN-SENSATION.

(a) **Temperature** :—1. Most and least sensible parts of the skin (including lips and tongue).

Find the order of sensitivity at a few specified points, recollecting that the parts which are habitually uncovered are more useful as sense organs than the rest. Quære : What points should be specified? Suggested : Inner surface of tip of forefinger, palm of hand, back of hand, upper surface of middle of forearm held palm upwards, forehead, nape of neck and cheeks (besides lips and tongue). Where the part is not median, the right side to be selected.

Mode of Testing :—Simple means appear to suffice for this. Weber and others have used phials of oil dipped in hot water. A more elaborate apparatus is a vessel of polished metal like a large but short test tube, and corked. A supply-pipe enters at the side of the cork and dips deeply in : a waste-pipe leads out at the other. These are connected with india-rubber tubes to appropriate vessels ; a thermometer, with its bulb nearly reaching the bottom, is set in the axis of the vessel, its scale being outside. In the thermoesthometer used by Klug, there was a septum down the middle, so that the water as it went through the instrument necessarily passed over the bottom and round the bulb of the thermometer. The time of contact should be uniform, say one second.

2. Degree at any part.—Least perceptible impression.—Least perceptible increment.—Highest impression not painful.

Quære : confine these tests to dipping the forefinger into vessels of water of different temperatures.

It appears from the experiments of Fechner and others, that note must always be made of the differences of temperature between that of the Test-object and its "Neutral-point," that is, the temperature at which the Test-object feels neither hot nor cold to the person under experiment.

It further appears, that the sensibility to small variations of temperature is greatest near the Neutral-point, where it is so delicate that it becomes exceedingly difficult to measure it with precision. An ordinary person, by dipping the finger to the same depth, alternately, into two basins of tepid water, can distinguish, under these circumstances, a difference of less than 0.2 Cent. (Fechner, *Psychophysik*. I., p. 203; Sir William Thomson, article *Heat*, *Encycl. Brit.*, 9th Ed., p. 559).

The full sense of warmth or cold is felt instantly upon dipping the finger, and water is the preferable liquid for simple tests. The changes of temperature in the vessel are under easy control, if the water that is added from time to time is only slightly warmer or colder than the temperature it is desired to attain.

The discriminating power rapidly diminishes when the temperature begins to exceed blood heat.

Some experimenters have employed the less quick and delicate test already mentioned, of making contact with the outside of thin vessels of polished metal, filled with hot water and jacketed with non-conducting material, except at the small surface where the test-contact is to take place. Such apparatus is necessary for testing the sensitivity of the skin elsewhere than in the fore-finger, which varies, according to NOTHNAGEL, from 0.2 C. in the hollow of the arm, to 1.2 C. in the middle of the back. The touching surface must be of a uniform and definite size (say 1 inch diameter).

Proposed Apparatus.—Two or more similar cylindrical vessels, say $4\frac{1}{2}$ inches wide and $5\frac{1}{2}$ high, with lids; each of them is filled by two supply pipes of hot and cold water, and its overflow is carried away by a waste pipe. The supply pipes dip deeply into the vessel, but not the waste pipe; the three issue side by side, and have stop-cocks; they are connected by india-rubber tubes with appropriate vessels. A knob above the lid is fixed to the prolonged vertical axis of a small rotating stirrer with vanes. Its axis is half-way between that of the vessel and one of its sides, consequently there is a free space between the opposite side of the vessel and the edge of the stirrer. The thermo-

meter passes through the lid into this space, and its bulb is freely exposed. Lastly, there is a hole in the lid, 2 inches diameter, through which the finger is dipped. The whole is surrounded by a non-conducting jacket (viz., by an outer vessel of larger diameter, and ashes are packed in the interspace).

The smallest distance apart, at which two simultaneous heat impressions can be distinguished from a single one, may be tested by the method of RAUBER, who used screens with two holes in them, which he held near the place to be tested, and brought a hot iron behind, which radiated heat through the holes. I find "tinder-cord," such as is used by smokers to strike light upon, to be a very manageable source of heat. A separate piece, that can be pushed to and fro in its tube, is used for each hole, each tube and its corresponding screen being fixed to an arm of an arrangement like a pair of compasses.

When the sun is shining, two burning foci will be thrown by the two halves of the same lens, if one is slid in advance of the other. The distance between the foci is equal to the amount of displacement of the two halves, and this may be indicated on a scale attached to one of them by a fiducial mark attached to or scratched on the other. If the sun is too hot, part of the lenses must be covered.

- (b) **Touch**:—1. Most and least sensitive parts of skin, (*a*) by least perceptible single impression; (*b*) by distinction of simultaneous impressions (compass points).

The same parts of the skin to be tested as those already tested for temperature.

The Least Perceptible Single Impression.—The delicacy of the sense of touch, especially in the face, is so great that it is scarcely possible to impose a definite pressure upon it, by any of the more obvious methods, that cannot be felt. All dragging of the touching object must be carefully avoided, and so must be the impact due to its swing. I have tried and rejected a large number of methods. Among these were morsels of cigarette paper, which is so thin that a leaf of it, containing 6 square inches, weighs only 1 grain; these were suspended by a filament of silk. It

was impossible to hold them steady, partly owing to the currents of warm air rising from the skin, partly from electrical attractions or repulsions. Kammler (Moleschott, *Untersuch.* 1858, p. 116), who used a similar method, employing cork or pith, had evidently much difficulty, judging from the run of his results, and from his remarks. Morsels of the same thin paper could not be dropped in any one desired and definite manner. A torsion needle was tried, mounted like a delicate galvanometer needle, but it was unsteady, and struck with a blow.

The only plan I have yet found to succeed, and it appears perfectly successful, is to make a coil of hair or light wire, consisting of not less than two and a half turns, with a diameter of about one-eighth of an inch. This is taken up by a pin fixed into the end of a pencil; the head of the pin being turned up, as a greater security against the coil falling off it. The axis of the coil always lies parallel to the pin on which it rests, and the coil touches the pin at only two points. The coil is brought above the place to be touched, held steady for a moment, and then, by slightly depressing the holder, it subsides upon the skin. A great range of weights can be used in this way; the lightest is a piece of human hair, curled round a hot knitting-pin into permanent shape, and weighing 0.002 grains; thence upwards through very thin aluminium wire, and very thin wire of other metals, up to stout brass wire. In all cases the coil should be, as nearly as may be, of the same length, and so far of the same diameter that the narrow band that comes in contact with the skin is practically of a uniform shape and area.

Distinction of Simultaneous Impressions.—A large bow-compass, or divider, worked with a screw, such as carpenters use, is more convenient than ordinary compasses. Some experimenters have employed a graduated bar, with a projecting rod at one end, and with a sliding-piece on the bar, carrying a corresponding projection. It is an instrument such as mechanics use for gauging thicknesses. It might be convenient to have sets of test-points, fitted in pairs on the sides of polygons, into holes that had been mechanically drilled at accurately measured distances.

2. Distinguishable qualities or kinds of Touch at any part.

A selection from the tests used for Active Touch (see § 4, below) would suffice for this; probably the emery papers would be the best.

3. Degree (at any part).—Least perceptible impression.—Least perceptible increment (passive appreciation of Weight).—Strongest impression (before sensibility is blunted or passes into pain).

Quære, as to the parts to be tested? Suggested: Inner surface of top of forefinger, palm of hand, forehead. The character of the two first tests has already been explained.

Strongest Impression.—A rod like a knitting pin, with rounded end and of specified diameter, is set like a pencil in a tube, but with a spiral spring behind that urges it forward. The test consists in pressing the point at right angles to the skin and noting the graduation when pain begins to be felt.

4. Active Touch or Pressure (involving "*Muscular Sense*") :—
Discrimination of Weights (by handling); of Hardness (by pushing); of Roughness (by surface movement); of Textures generally (by combined or opposed movements of thumb and fingers).

Discrimination of Weights by Handling.—I have lately described an apparatus that acts well. It consists of a set of common gun cartridges, stuffed with various weights of shot, wool, and wad, and closed in the usual way. They form geometric sequences of test-objects, and are consequently separated by what may be considered approximately as "equally perceptible differences." The sensitivity is therefore inversely proportional to the number of grades in the series intervening between any two just distinguishable test-objects. I have hitherto used the weights in sets of threes, but for the future I should prefer sets of twos.

An apparatus on the model of that of Fechner, which he ultimately adopted after large practical experience, would be used for heavier weights.

Discrimination of Hardness.—As hardness means resistance, we may use a series of knobs, to serve as keys, like those of a concertina. Each knob would stand on one end of a concealed lever, of which the other end is weighted. The weights would run in a geometric series. If the levers are long, say 12 inches, their mode of suspension may be very rude, and yet effective.

Discrimination of Roughness.—The test-objects to be of the same material, but of different degrees of coarseness. Emery powder is sold (by Oakey) of twenty-one different sizes, sorted through graduated holes of the following number to the inch:

120, 110, 100, 90, 80, 70, 60, 54, 46, 40, 36, 30, 24, 20, 18, 16, 14, 12, 10, 9, 8. A selection of these would serve as tests. Or they might be used (as Dr. Mahomed suggested) in the form of emery paper. In this case strips of the series of test-papers, 1 inch wide, might be pasted in parallel columns on a sheet, with half-inch intervals between them; after that, the sheet would be cut transversely into bands of an inch wide, each band containing a sequence of the samples, each of one square inch in size.

Textures.—Query as to the best for the purpose.

Power of Localising Impressions.—Measure of Extension, with different parts moving or at rest. Quære, whether the same parts only that have been already specified should be tested in this respect?

The methods of testing are obvious; the result to be aimed at in each case is the Mean Error.

Comparative Sensibility, right or left.—The parts to be tested would probably be left to the discretion of the operator according to circumstances, the difference being the most interesting in cases of left-handedness.