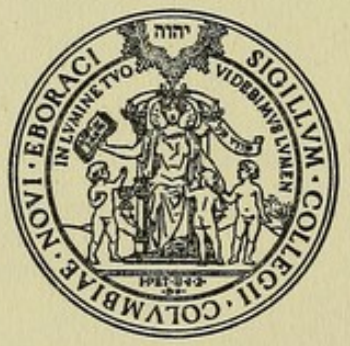
Experimental researches on the temperature of the head / By J. S. Lombard.

THE NORMAL TEMPERATURE OF THE HEAD

J. S. LOMBARD



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EXPERIMENTAL RESEARCHES

ON THE

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BY

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LONDON:
H. K. LEWIS, 136, GOWER STREET.
1881.

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ON SOME POINTS RELATING TO THE

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NORMAL TEMPERATURE

OF

THE HEAD.

In a recently published work the writer of this article has given an account of investigations made by him on the temperature of the head, extending almost uninterruptedly over a space of more than two years.* In these investigations the surface of the head was divided by measurement into a number of small spaces (eighty-eight on each side), which were examined separately and by comparison with each other. Both thermometers and thermo-electric apparatus were employed in the experiments, the chief reliance, however, being placed on thermo-electric apparatus, as in the use of thermometers—among other sources of error—the temperature of the superficial vessels of the integument influences the result, the pressure of the instrument not being sufficient to empty these vessels, which can readily be compressed by the firm application of suitably constructed thermo-piles. It was found in these experiments, among other results, that every one of the small divisions of the surface of the head might be hotter on the right side or on the left side in turn, and also that many of them showed at times equality of temperature of the two sides. In this absence of a constant superiority of temperature on one side, the writer's results were in opposition to those of M. Broca, Dr. Gray, and MM. Mantegazza, and Seppilli, who came to the conclusion that the left side has uniformly the higher temperature.

* 'Experimental Researches on the Regional Temperature of the Head.' London 1879.

Now the idea long ago suggested itself to the writer that *the degree of absolute temperature* of the parts examined might have something to do with the presence on the right side at one time, and on the left side at another time, of superiority of temperature, or again, with the presence, at certain times, of equality of temperature. In fact, a considerable number of observations seemed to show that near the higher limit of range of absolute temperature equality and superiority of temperature of the left side prevailed, while superiority of temperature of the right side was the most frequent condition at a lower absolute temperature.

To understand the different circumstances under which the temperatures of two parts may vary, so as to leave each one in turn warmer than the other, let us imagine a condition of things such as the following:—Suppose that of the two parts compared, one, "a," is, in the first place warmer, and, in the second place, cooler than the other, "b." When, in the second instance, "b" surpasses "a" in temperature, one of five things may have occurred, namely:—First, "b" may have risen in temperature in a degree exceeding the difference between it and "a," the temperature of the latter remaining constant; second, "a" may have fallen below the level of "b," the temperature of the latter being unaffected; third, both parts may have risen in temperature, "b," however, rising in a sufficiently greater degree than "a" to attain a higher final level than the latter; fourth, both parts may have fallen in temperature, the fall of "a" being, however, sufficiently greater than that of "b," to leave the former at the lower final level; fifth, "a" may have fallen and "b" have risen in temperature, the fall and rise being sufficient to leave "b" at the higher final level.

If we regard the thermal values of "a" and "b" as represented in the first place, by the temperatures 35·1° C., and 35° C. respectively, the following will represent the changes specified:

1st Instance.		2nd Instance.		3rd Instance.	
"a"	"b"	"a"	"b"	"a"	"b"
35·1° C.	35° C.	35·1° C.	35·2° C.	34·9° C.	35° C.

4th Instance.		5th Instance.		6th Instance.	
"a"	"b"	"a"	"b"	"a"	"b"
35·2° C.	35·3° C.	34·8° C.	34·9° C.	34·95° C.	35·05° C.

In all these instances the initial difference of 0·1° C. between the two parts is preserved.

Suppose, now, that in a given number of observations "a" is found to be the warmer by 0·1° C. with an absolute temperature of 35·1° C., while in another set of observations "b" is found to be the warmer by 0·1° C. with an absolute temperature of 34·1° C. If these observations were sufficiently numerous the inference would be that "a" has usually the greater range of temperature of the two parts, rising higher and falling lower than "b." In rising and falling between the above extremes a point must be touched at which "a" and "b" have the same temperatures. This point may, of course, be nearer either one of the extremes or midway between them. Above the neutral point "a" would have the higher temperature, while below this point "b" would be the warmer. But between the two extremes the position of superior temperature may alter more than once, and thus more than one neutral point may occur.

The following arrangement of thermometric values would represent such a condition of things as that alluded to. The "plus" sign is placed opposite the higher of the two values compared, and "zero" opposite equal values or neutral points.

	"a"		"b"	
	+35·1° C.	. . .	35° C.	
0	34·75° C.	. . .	34·75° C.	0
	34·40° C.	. . .	34·50° C.+	
0	34·35° C.	. . .	34·35° C.	0
	+34·35° C.	. . .	34·25° C.	
0	34·20° C.	. . .	34·20° C.	0
	34·00° C.	. . .	34·10° C.+	

Here we have the higher temperature twice in favour of each part, with three neutral points.

But although the neutral point must necessarily be touched at each reversal of position of the higher temperature,

yet it by no means follows that the temperatures of the two parts remain equal sufficiently long to enable one to prove the existence of neutrality with the instruments ordinarily used. The duration of the condition of equality may be too brief to be noticeable except by means of delicate self-registering appliances. It must, moreover, be borne in mind that equality of temperature is, at best, a *relative* condition depending upon the delicacy of the means of investigation employed; thus—other things remaining the same—equality would naturally be found more frequently with instruments incapable of testing difference of temperature less than 0·1° C. than with those capable of testing differences of 0·05° C. Further, the neutral point may be touched and held sufficiently long for satisfactory verification without subsequent reversal of the position of higher temperature ensuing. Again, the writer has called attention, in the work already cited, to the curious absence of any definite connection between the frequency of occurrence of neutrality or of superiority of temperature on a side, in the comparison of two parts, and the average thermometric difference displayed by these two parts. Thus, two parts with a comparatively slight average difference of temperature, being thus, as it were, constantly on the verge of equality or of a change of position of higher temperature from one side to the other, may yet seldom show equality or a change of the position of higher temperature from one side to the other, while two other parts, with a much greater average difference of temperature, may more frequently show equality or a change in the position of superiority of temperature from one side to the other. For example, two parts, "a" and "b," with an average difference of temperature of 0·05° C., may show 80 per cent. of cases of higher temperature for "a," 19 per cent. of cases of higher temperature for "b," and 1 per cent. of cases of equality of temperature; while two parts, "c" and "d," with an average difference of temperature of 0·2° C., may show 50 per cent. of cases of higher temperature for "c," 38 per cent. of cases of higher temperature for "d," and 12 per cent. of equality of temperature. These facts show that the variations of temperature with which we are concerned are, in a considerable

measure at least, not simply the result of steady and gradual rises and falls of temperature, differing slightly in degree in the two parts compared, due to regular alterations in the rate of calorific production alone, but that the furnaces, which we may suppose the parts to represent, are, in many cases at any rate, liable to sudden and decided interferences with their ordinary action, causing rapid and irregular exaltations and depressions of their powers, and this in each part independently of the other. Thus, it is evident that in the case of "c" and "d" given above, in order to furnish such relative percentages of those set forth, quick rises or falls of temperature of 0·2° C., at the least, must have occurred, every time equality ensued this difference having to be made up, and, of course, a still greatest deficit having to be supplied with each reversal of the position of higher temperature.

If the extreme limits of thermal range, beyond which no rise or fall can normally occur, be the same or nearly the same in the two parts compared, it follows, of course, that, in a united rise or fall of temperature in both parts, as these limits are approached the average degree of difference of temperature would naturally tend to diminish, until finally, when the bounds were reached, either equality would be present, or a minimum difference of temperature in favour of that particular part the extreme thermal limit of which had the highest absolute level. But even with the extreme limits nearly the same, and with a united rise or fall in the two parts towards a higher or lower general level, this rise or fall may be very unequal in the two parts at different periods, and thus not only may frequent shiftings of the position of higher temperature from one side to the other occur, but also all shades of difference of temperature may be found at different levels, according as the rate of rise or fall varies in the two parts independently of each other. Therefore, in the hypothetical case given on page 5, of a rise from 34° C. to 35·1° C., the uniform difference of temperature of 0·1° C., given for the sake of simplification, would not probably be maintained throughout; but although, as the general level rose the average difference might diminish, yet even almost to the extreme upper limit—supposing the rise

to pass decidedly above 35·1° C.—irregular variations might bring about as great differences as those found at the lower levels.

Such being a general idea of the conditions under which the temperatures of two parts may alter so as to leave each part at certain times superior in temperature to the other, or again, at other times, both parts equal in temperature, let us see what the results of our investigations show with regard to the influence of the degree of absolute temperature of the head on the frequency of occurrence of superiority of temperature on a given side or of equality of temperature of the two sides.

In the present article the writer proposes to analyse the results of some 6000 observations bearing on the questions in hand. These observations are contained in four tables, constituting each a separate and distinct set of experiments. The experiments were made on three subjects, the mental and physical conditions of whom were thoroughly known to the experimenter, and under circumstances where all external influences likely to affect the results were under careful supervision.* The division of the results into the four tables is purely accidental, depending simply on the fact that the observations were made at different periods, each period corresponding to the contents of a table. Each table, therefore, represents an independent series of experiments covering the greater part of the different absolute temperatures which are found normally in the portion of the head examined.

The part of the head examined lies back of the external angular process, and is thus bounded:—Anteriorly, by the external angular process, the frontal process of the malar bone, and by a line drawn upward from the external angular process parallel to the general plane of the forehead; posteriorly, by a line drawn upward from the zygomatic process of the temporal bone parallel to the anterior boundary line, and at a distance from it of 37 mm.; superiorly, by a horizontal line drawn on a level with the summit of the superciliary arch; inferiorly, by the zygomatic processes of the

* The writer has elsewhere laid much stress on the importance of this intimate knowledge of the subject of experiment, and of the physical surroundings in which such experiments are made.

malar and temporal bones. The tract thus marked off includes of the writer's abitrary subdivisions, the 5th district, 1st tier, anterior region, and the 1st district, 1st tier, middle region, and covers the "frontal station" of Broca, adopted also by Gray and by Marigliano and Seppilli.

In making the experiments, the absolute temperature of one side—usually the left side—was first obtained, sometimes with the thermometer, and sometimes with thermo-electric apparatus; the difference of temperature between the two sides was then taken, always using for this purpose thermo-electric apparatus, and this difference, added to or deducted from the absolute temperature first obtained, gave the absolute temperature of the second side. After a certain number of comparisons the absolute temperature of the first side was again tested, and the averages obtained from the several examinations taken to represent the results of that particular set of observations. The method of taking the absolute temperature by thermo-electric means, although open to objections obvious to those accustomed to such investigations, is yet, in experienced hands, on the whole more satisfactory in work like the present than the use of the thermometer; for the former method can be conducted rapidly and repeated frequently, while the latter requires a far greater length of time, during which no comparisons of the two sides can be made, and, moreover, by the covering up of the part by the appliances necessary to protect and keep in place the bulb of the thermometer, augments the temperature of the part.

It will be observed in the tables, that the number of observations belonging to each absolute temperature is either fifteen or some product of this number. The reason of this is as follows. The object of the investigations was to find, in the case of each absolute temperature, which of the three conditions, namely, superiority of the right side, superiority of the left side, or equality of the two sides, was most frequently present. Now, suppose an examination at a given time, with an absolute temperature of 34·5° C. (92·1° F.) on the left side, shows the right side to be the hotter by 0·1° C. (0·18° F.). Continuing to compare the two sides with thermo-piles, we might go on for half an hour or an hour, still finding the right side the warmer by an amount equal

to, or a little more or less than, that first found; but the *number of comparisons* which could be made in the times specified might vary greatly at different periods and under different circumstances. A number of experimental conditions beyond the control of the experimenter influence the rapidity with which such observations can be made. At one time the experimenter might proceed at the rate of an observation every half minute, while at another time several minutes might be spent with no certain result, and yet no change might have occurred in the relative temperatures of the parts compared. It would be out of place and occupy too much space to deal here with these causes of interference, which have, moreover, been fully considered by the writer in the work alluded to; it suffices to say that, through them, the number of observations which can be made in a given time may be decidedly affected. While, therefore, in half an hour, on one occasion, with the absolute temperature 34·5° C. (92·1° F.), we might obtain sixty results in favour of the right side, in the same time, with the same temperature, on another occasion, the superiority being now on the left side, we might obtain but fifteen results in favour of the latter side. Now to say that, at the particular temperature in question, the percentages of times of occurrence of superiority of temperature of the right and left sides are respectively 80 and 20, as the above results would indicate, would be to commit an obvious error.

The method pursued in these investigations was:—After finding the absolute temperature of one side, to make fifteen careful comparisons of the two sides. If the results of these comparisons were uniformly in favour of a single side or of equality, and if, in the former case, the differences of temperature noted were pretty nearly the same, the results were set down as so many observations for that particular absolute temperature. Nothing more was recorded for the time, but the temperature was tested at short intervals to see if any change occurred either in the absolute temperature of the side first examined, or in the relative temperatures of the two sides. If the absolute temperature changed, of course a new series of observations were made, and fifteen results were recorded for this new temperature. The same course

was pursued if the position of higher temperature changed sides, or if equality was substituted for superiority of a side, or, finally, if the difference of temperature between the two sides underwent any decided change. But if no change occurred in the space of three quarters of an hour, fifteen more results, taken from those meanwhile made, were added; and so on until a change occurred. If, on the other hand, at the start, during the first fifteen observations, any decided change took place, such as, for example, a reversal of the position of higher temperature, the course adopted was governed by the number of observations already made. If only two or three of the fifteen observations had been made the results were ignored. If only the same number were wanting to make up the fifteen, the full complement was counted as made. If half, or about half, of the full number had been made, they were put aside to be used to the credit of the particular condition which they represented in some future set of observations in which the same absolute temperature existed, thus going to make up another complement of fifteen. As a rule, however, the entire fifteen observations were completed at one time without interruption.

We will now proceed to examine the tables.

Each table is divided into two parts. The first part comprises those cases in which the higher of the two temperatutes compared is 35° C. (95° F.), or above that point; and the second part comprises those cases in which the higher of the two temperatures compared is below 35° C. The first two columns consist of the absolute temperatures of the two sides; the figures of the third and fourth columns are the differences of temperature in favour of one side or the other as the case may be; the fifth column gives the number of observations, and the sixth column indicates whether the results are in favour of the right side, or of the left side, or of equality of the two sides.

The tables will be analysed in two principal ways :—First, by comparing the percentages of frequency of occurrence of the conditions of right and left superiority of temperature and of equality of temperature respectively, in the two parts into which each table is divided; and, second, by comparing the average absolute temperatures of the three conditions.

Table 1.

1st Part.—Cases where the higher of the two temperatures compared is 35° C., or above that point.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
35·90000° C.	36·12500° C.	0	0·22500° C.	15	Right side
35·90000° C.	35·97500° C.	0	0·07500° C.	,,	,,
35·90000° C.	35·90000° C.	0	0	,,	Equality
35·90000° C.	35·67500° C.	0·22500° C.	0	,,	Left side
35·80000° C.	35·95000° C.	0	0·15000° C.	,,	Right side
35·75000° C.	35·90000° C.	0	0·15000° C.	,,	,,
35·75000° C.	35·75000° C.	0	0	,,	Equality
35·75000° C.	35·67500° C.	0·07500° C.	0	,,	Left side
35·70000° C.	35·81250° C.	0	0·11250° C.	,,	Right side
35·70000° C.	35·70000° C.	0	0	,,	Equality
35·70000° C.	35·51250° C.	0·18750° C.	0	,,	Left side
35·60000° C.	35·90000° C.	0	0·30000° C.	,,	Right side
35·60000° C.	35·77490° C.	0	0·17490° C.	,,	,,
35·55000° C.	35·66250° C.	0	0·11250° C.	,,	,,
35·55000° C.	35·55000° C.	0	0	,,	Equality
35·55000° C.	35·47500° C.	0·07500° C.	0	,,	Left side
35·50000° C.	35·65000° C.	0	0·15000° C.	30	Right side
35·50000° C.	35·45000° C.	0·05000° C.	0	15	Left side
35·50000° C.	35·05000° C.	0·45000° C.	0	,,	,,
35·45000° C.	35·45000° C.	0	0	,,	Equality
35·40000° C.	35·17500° C.	0·22500° C.	0	,,	Left side
35·40000° C.	35·62500° C.	0	0·22500° C.	,,	Right side
35·40000° C.	35·47500° C.	0	0·07500° C.	,,	,,
35·40000° C.	35·40000° C.	0	0	,,	Equality
35·25000° C.	35·32500° C.	0	0·07500° C.	,,	Right side
35·25000° C.	35·25000° C.	0	0	,,	Equality
35·20000° C.	35·42500° C.	0	0·22500° C.	,,	Right side
35·20000° C.	35·20000° C.	0	0	60	Equality
35·20000° C.	35·35000° C.	0	0·15000° C.	15	Right side
35·20000° C.	34·93750° C.	0·26250° C.	0	,,	Left side
35·15000° C.	35·18750° C.	0	0·03750° C.	,,	Right side
35·15000° C.	35·15000° C.	0	0	,,	Equality
35·10000° C.	35·21250° C.	0	0·11250° C.	,,	Right side
35·10000° C.	35·25000° C.	0	0·15000° C.	30	,,
35·10000° C.	35·10000° C.	0	0	15	Equality
35·05000° C.	35·23750° C.	0	0·18750° C.	,,	Right side
35·05000° C.	34·90000° C.	0·15000° C.	0	,,	Left side
35·00000° C.	35·15000° C.	0	0·15000° C.	,,	Right side

Table 1.

2nd Part.—Cases where the higher of the two temperatures compared is below 35° C.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
34·90000° C.	34·90000° C.	0	0	15	Equality
34·90000° C.	34·72501° C.	0·17499° C.	0	30	Left side
34·80000° C.	34·95000° C.	0	0·15000° C.	15	Right side
34·80000° C.	34·87500° C.	0	0·07500° C.	„	„
34·80000° C.	34·80000° C.	0	0	„	Equality
34·80000° C.	34·65000° C.	0·15000° C.	0	„	Left side
34·75000° C.	34·97500° C.	0	0·22500° C.	„	Right side
34·75000° C.	34·75000° C.	0	0	„	Equality
34·65000° C.	34·53750° C.	0·11250° C.	0	„	Left side
34·60000° C.	34·71250° C.	0	0·11250° C.	„	Right side
34·60000° C.	34·52500° C.	0·07500° C.	0	„	Left side
34·60000° C.	34·60000° C.	0	0	„	Equality
34·60000° C.	34·24000° C.	0·36000° C.	0	30	Left side
34·55000° C.	34·77500° C.	0	0·22500° C.	15	Right side
34·55000° C.	34·75625° C.	0	0·20625° C.	„	„
34·55000° C.	34·55000° C.	0	0	30	Equality
34·55000° C.	34·32500° C.	0·22500° C.	0	15	Left side
34·40000° C.	34·55000° C.	0	0·15000° C.	„	Right side
34·40000° C.	34·40000° C.	0	0	„	Equality
34·40000° C.	34·10000° C.	0·30000° C.	0	„	Left side
34·30000° C.	34·46249° C.	0	0·16249° C.	30	Right side
34·30000° C.	34·30000° C.	0	0	15	Equality
34·25000° C.	34·10000° C.	0·15000° C.	0	„	Left side
34·20000° C.	34·47000° C.	0	0·27000° C.	30	Right side
34·20000° C.	34·27500° C.	0	0·07500° C.	15	„
34·20000° C.	34·20000° C.	0	0	45	Equality
34·20000° C.	33·70002° C.	0·49998° C.	0	30	Left side
34·15000° C.	34·45000° C.	0	0·30000° C.	15	Right side
34·10000° C.	34·10000° C.	0	0	„	Equality
34·05000° C.	33·80001° C.	0·24999° C.	0	„	Left side
33·95000° C.	34·40000° C.	0	0·45000° C.	„	Right side
33·65000° C.	33·95000° C.	0	0·30000° C.	„	„
33·45000° C.	33·75000° C.	0	0·30000° C.	„	„
33·10000° C.	33·02500° C.	0·07500° C.	0	„	Left side
33·10000° C.	33·32500° C.	0	0·22500° C.	„	Right side

Table 2.

1st Part.—Cases where the higher of the two temperatures compared is 35° C., or above that point.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
36·10000° C.	35·98750° C.	0·11250° C.	0	15	Left side
36·10000° C.	36·32500° C.	0	0·22500° C.	„	Right side
36·10000° C.	36·10000° C.	0	0	„	Equality
35·90000° C.	35·99999° C.	0	0·09999° C.	„	Right side
35·90000° C.	35·90000° C.	0	0	30	Equality
35·80000° C.	35·95000° C.	0	0·15000° C.	15	Right side
35·80000° C.	35·80000° C.	0	0	30	Equality
35·80000° C.	36·04375° C.	0	0·24375° C.	15	Right side
35·80000° C.	35·68750° C.	0·11250° C.	0	„	Left side
35·75000° C.	35·87499° C.	0	0·12499° C.	„	Right side
35·75000° C.	35·75000° C.	0	0	30	Equality
35·75000° C.	35·63750° C.	0·11250° C.	0	15	Left side
35·60000° C.	35·67500° C.	0	0·07500° C.	„	Right side
35·60000° C.	35·60000° C.	0	0	„	Equality
35·60000° C.	35·41250° C.	0·18750° C.	0	„	Left side
35·55000° C.	35·70000° C.	0	0·15000° C.	„	Right side
35·50000° C.	35·68750° C.	0	0·18750° C.	„	„
35·50000° C.	35·50000° C.	0	0	„	Equality
35·50000° C.	35·20000° C.	0·30000° C.	0	„	Left side
35·45000° C.	35·45000° C.	0	0	„	Equality
35·40000° C.	35·47500° C.	0	0·07500° C.	„	Right side
35·40000° C.	35·21250° C.	0·18750° C.	0	„	Left side
35·20000° C.	35·27500° C.	0	0·07500° C.	„	Right side
35·20000° C.	35·20000° C.	0	0	30	Equality
35·15000° C.	35·30000° C.	0	0·15000° C.	15	Right side
35·05000° C.	35·27500° C.	0	0·22500° C.	„	„
35·00000° C.	35·22500° C.	0	0·22500° C.	„	„
35·00000° C.	35·00000° C.	0	0	„	Equality

Table 2.

2nd Part.—Cases where the higher of the two temperatures compared is below 35° C.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
34·90000° C.	34·97500° C.	0	0·07500° C.	15	Right side
34·90000° C.	34·90000° C.	0	0	„	Equality
34·70000° C.	34·92500° C.	0	0·22500° C.	„	Right side
34·70000° C.	34·40000° C.	0·30000° C.	0	„	Left side
34·65000° C.	34·87500° C.	0	0·22500° C.	„	Right side
34·65000° C.	34·35000° C.	0·30000° C.	0	„	Left side
34·60000° C.	34·79500° C.	0	0·19500 C.	„	Right side
34·60000° C.	34·60000° C.	0	0	„	Equality
34·60000° C.	34·52500° C.	0·07500° C.	0	„	Left side
34·55000° C.	34·79375° C.	0	0·24375° C.	„	Right side
34·40000° C.	34·55000° C.	0	0·15000° C.	„	„
34·40000° C.	34·49999° C.	0	0·09999° C.	„	„
34·40000° C.	34·28750° C.	0·11250° C.	0	„	Left side
34·40000° C.	34·40000° C.	0	0	„	Equality
34·30000° C.	34·60000° C.	0	0·30000° C.	„	Right side
34·30000° C.	34·37500° C.	0	0·07500° C.	„	„
34·30000° C.	34·30000° C.	0	0	„	Equality
34·30000° C.	34·00000° C.	0·30000° C.	0	„	Left side
34·20000° C.	34·57500° C.	0	0·37500° C.	„	Right side
34·10000° C.	34·13750° C.	0	0·03750° C.	„	„
34·10000° C.	34·10000° C.	0	0	„	Equality
34·05000° C.	33·92501° C.	0·12499° C.	0	„	Left side
34·05000° C.	34·24998° C.	0	0·19998° C.	„	Right side
33·95000° C.	34·25000° C.	0	0·30000° C.	„	„
33·52500° C.	33·67500° C.	0	0·15000° C.	„	„
33·52500° C.	33 52500° C.	0	0	„	Equality
33·10000° C.	33·25000° C.	0	0·15000° C.	„	Right side
33·10000° C.	32·87500° C.	0·22500° C.	0	„	Left side

Table 3.

1st Part.—Cases where the higher of the two temperatures compared is 35° C., or above that point.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
35·70000° C.	35·75555° C.	0	0·05555° C.	15	Right side
35·70000° C.	35·72777° C.	0	0·02777° C.	„	„
35·70000° C.	35·70000° C.	0	0	30	Equality
35·65000° C.	35·53889° C.	0·11111° C.	0	15	Left side
35 60000° C.	35·71111° C.	0	0·11111° C.	30	Right side
35·50000° C.	35·61111° C.	0	0·11111° C.	15	„
35·50000° C.	35·77775° C.	0	0·27775° C.	„	„
35·50000° C.	35·58333° C.	0	0·08333° C.	„	„
35·50000° C.	35·55555° C.	0	0·05555° C.	„	„
35·50000° C.	35·50000° C.	0	0	„	Equality
35·40000° C.	35·51111° C.	0	0·11111° C.	45	Right side
35·40000° C.	35·48333° C.	0	0·08333° C.	30	„
35·40000° C.	35·45555° C.	0	0·05555° C.	15	„
35·40000° C.	35·44166° C.	0	0·04166° C.	„	„
35·40000° C.	35·40000° C.	0	0	45	Equality
35·40000° C.	35·34445° C.	0·05555° C.	0	15	Left side
35·40000° C.	35·35834° C.	0·04166° C.	0	„	„
35·35000° C.	35·46111° C.	0	0·11111° C.	30	Right side
35·35000° C.	35·40555° C.	0	0·05555° C.	15	„
35·35000° C.	35·37777° C.	0	0·02777° C.	„	„
35·35000° C.	35·35000° C.	0	0	30	Equality
35·30000° C.	35·41111° C.	0	0·11111° C.	„	Right side
35·30000° C.	35·46666° C.	0	0·16666° C.	15	„
35·30000° C.	35·35555° C.	0	0·05555° C.	„	„
35·30000° C.	35·30000° C.	0	0	45	Equality
35·30000° C.	35·20277° C.	0·09723° C.	0	30	Left side
35·30000° C.	35·17222° C.	0·12778° C.	0	15	„
35·25000° C.	35·47222° C.	0	0·22222° C.	30	Right side
35·20000° C.	35·56110° C.	0	0·36110° C.	15	„
35·20000° C.	35·36666° C.	0	0·16666° C.	„	„
35·20000° C.	35·31111° C.	0	0·11111° C.	30	„
35·20000° C.	35·26944° C.	0	0·06944° C.	„	„
35·15000° C.	35·26111° C.	0	0·11111° C.	„	„
35·15000° C.	35·24444° C.	0	0·09444° C.	15	„
35·15000° C.	35·15000° C.	0	0	„	Equality
35·10000° C.	35·32222° C.	0	0·22222° C.	„	Right side
35·10000° C.	35·23888° C.	0	0·13888° C.	„	„
35·10000° C.	35·21111° C.	0	0·11111° C.	„	„
35·10000° C.	35·19722° C.	0	0·09722° C.	„	„
35·10000° C.	35·05834° C.	0·04166° C.	0	„	Left side
35·05000° C.	35·27222° C.	0	0·22222° C.	„	Right side
35·00000° C.	35·11111° C.	0	0·11111° C.	45	„
35·00000° C.	35·08333° C.	0	0·08333° C.	15	„
35·00000° C.	35·00000° C.	0	0	30	Equality
35·00000° C.	34·93056° C.	0·06944° C.	0	15	Left side
34·95000° C.	35·06111° C.	0	0·11111° C.	„	Right side
34·90000° C.	35·12222° C.	0	0·22222° C.	„	„
34·90000° C.	35·01111° C.	0	0·11111° C.	„	„

Table 3.

2nd Part.—Cases where the higher of the two temperatures compared is below 35° C.

Absolute temperatures.		Differences of temperature. In favour of		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
34·90000° C.	34·99722° C.	0	0·09722° C.	45	Right side
34·90000° C.	34·95555° C.	0	0·05555° C.	30	„
34·90000° C.	34·78889° C.	0·11111° C.	0	15	Left side
34·90000° C.	34·90000° C.	0	0	30	Equality
34·85000° C.	34·91944° C.	0	0·06944° C.	„	Right side
34·85000° C.	34·62778° C.	0·22222° C.	0	15	Left side
34·80000° C.	34·96666° C.	0	0·16666° C.	30	Right side
34·75000° C.	34·69445° C.	0·05555° C.	0	15	Left side
34·75000° C.	34·84722° C.	0	0·09722° C.	30	Right side
34·75000° C.	34·75000° C.	0	0	45	Equality
34·75000° C.	34·63889° C.	0·11111° C.	0	15	Left side
34·70000° C.	34·97777° C.	0	0·27777° C.	30	Right side
34·60000° C.	34·82222° C.	0	0·22222° C.	„	„
34·60000° C.	34·54445° C.	0·05555° C.	0	15	Left side
34·55000° C.	34·43889° C.	0·11111° C.	0	„	„
34·50000° C.	34·68055° C.	0	0·18055° C.	30	Right side
34·40000° C.	34·45555° C.	0	0·05555° C.	15	„
34·35000° C.	34·46111° C.	0	0·11111° C.	45	„
34·30000° C.	34·18889° C.	0·11111° C.	0	15	Left side
34·30000° C.	34·57777° C.	0	0·27777° C.	30	Right side
34·25000° C.	34·30555° C.	0	0·05555° C.	15	„
34·20000° C.	34·31111° C.	0	0·11111° C.	30	„
34·20000° C.	34·14445° C.	0·05555° C.	0	15	Left side
34·07500° C.	34·35277° C.	0	0·27777° C.	30	Right side
33·80000° C.	34·10555° C.	0	0·30555° C.	15	„

Table 4.

1st Part.—Cases where the higher of the two temperatures compared is 35° C., or above that point.

Absolute temperatures.		Differences of temperature. In favour of.		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
36·40000° C.	36·40000° C.	0	0	15	Equality
36·30000° C.	36·22500° C.	0·07500° C.	0	„	Left side
36·20000° C.	36·20000° C.	0	0	„	Equality
36·20000° C.	36·12500° C.	0·07500° C.	0	„	Left side
36·15000° C.	36·15000° C.	0	0	30	Equality
36·15000° C.	36·03889° C.	0·11111° C.	0	15	Left side
36·10000° C.	36·10000° C.	0	0	„	Equality
36·10000° C.	36·00000° C.	0·10000° C.	0	„	Left side
36·00000° C.	35·90000° C.	0·10000° C.	0	„	„ „
36·00000° C.	36·07500° C.	0	0·07500° C.	„	Right side
36·00000° C.	36·00000° C.	0	0	30	Equality
36·00000° C.	35·85000° C.	0·15000° C.	0	„	Left side
36·00000° C.	36·15000° C.	0	0·15000° C.	15	Right side
35·95000° C.	35·87500° C.	0·07500° C.	0	„	Left side
35·90000° C.	35·78889° C.	0·11111° C.	0	45	„ „
35·90000° C.	35·90000° C.	0	0	„	Equality
35·90000° C.	36·01111° C.	0	0·11111° C.	15	Right side
35·85555° C.	35·80000° C.	0·05555° C.	0	30	Left side
35·85000° C.	35·90555° C.	0	0·05555° C.	15	Right side
35·80000° C.	35·93888° C.	0	0·13888° C.	60	„ „
35·80000° C.	35·85555° C.	0	0·05555° C.	75	„ „
35·80000° C.	35·68889° C.	0·11111° C.	0	15	Left side
35·80000° C.	35·80000° C.	0	0	30	Equality
35·75000° C.	35·86111° C.	0	0 11111° C.	„	Right side
35·75000° C.	35·75000° C.	0	0	15	Equality
35·70000° C.	35·75555° C.	0	0·05555° C.	„	Right side
35·65000° C.	35·76111° C.	0	0·11111° C.	„	„ „
35·65000° C.	35·53889° C.	0·11111° C.	0	„	Left side
35·60000° C.	35·48889° C.	0·11111° C.	0	30	„ „
35·60000° C.	35·68333° C.	0	0·08333° C.	15	Right side
35·55000° C.	35·66000° C.	0	0·11000° C.	„	„ „
35·55000° C.	35·55000° C.	0	0	„	Equality
35·50000° C.	35·77775° C.	0	0·27775° C.	90	Right side
35·50000° C.	35·38889° C,	0·11111° C.	0	45	Left side
35·50000° C.	35·50000° C.	0	0	30	Equality
35·45000° C.	35·56111° C.	0	0·11111° C.	15	Right side
35·40000° C.	35·45555° C.	0	0·05555° C.	„	„ „
35·40000° C.	35·28889° C.	0·11111° C.	0	„	Left side
35·40000° C.	35·32223° C.	0·07777° C.	0	„	„ „
35·40000° C.	35·40000° C.	0	0	„	Equality
35·35000° C.	35·51666° C.	0	0·16666° C.	30	Right side
35.35000° C.	35·37777° C.	0	0·02777° C.	15	„ „
35·35000° C.	35·18334° C.	0·16666° C.	0	„	Left side
35·35000° C.	35·35000° C.	0	0	„	Equality
35·30000° C.	35·46666° C.	0	0·16666° C.	„	Right side
35·30000° C.	35·24445° C.	0·05555° C.	0	„	Left side
35·30000° C.	35·41111° C.	0	0·11111° C.	„	Right side
35·25000° C.	35·18056° C.	0·06944° C.	0	„	Left side
35·20000° C.	35·25555° C.	0	0·05555° C.	30	Right side

Absolute temperatures.		Differences of temperature. In favour of.		Number of observations.	Result in favour of
Left side.	Right side.	Left side.	Right side.		
35·20000° C.	35·20000° C.	0	0	45	Equality
35·00000° C.	35·11111° C.	0	0·11111° C.	15	Right side
35·00000° C.	35·00000° C.	0	0	„	Equality
35·00000° C.	34·97223° C.	0·02777° C.	0	„	Left side
35·00000° C.	34·88889° C.	0·11111° C.	0	30	„ „
34·90000° C.	35·01111° C.	0	0·11111° C.	15	Right side

Table 4.

2nd Part.—Cases where the higher of the two temperatures compared is below 35° C.

34·90000° C.	34·95555° C.	0	0·05555° C.	15	Right side
34·90000° C.	34·78889° C.	0 11111° C.	0	„	Left side
34·90000° C.	34·90000° C.	0	0	„	Equality
34·85000° C.	34·98888° C.	0	0·13888° C.	30	Right side
34·85000° C.	34·79445° C.	0·05555° C.	0	„	Left side
34·80000° C.	34·91111° C.	0	0·11111° C.	„	Right side
34·80000° C.	34·80000° C.	0	0	15	Equality
34·80000° C.	34·68889° C.	0·11111° C.	0	„	Left side
34·75000° C.	34·86111° C.	0	0·11111° C.	30	Right side
34·70000° C.	34·47778° C.	0·22222° C.	0	15	Left side
34·65000° C.	34·81666° C.	0	0·16666° C.	45	Right side
34·65000° C.	34·53889° C.	0·11111° C.	0	15	Left side
34·60000° C.	34·71111° C.	0	0·11111° C.	30	Right side
34·60000° C.	34·60000° C.	0	0	15	Equality
34·60000° C.	34·37778° C.	0·22222° C.	0	15	Left side
34·55000° C.	34·66111° C.	0	0·11111° C.	30	Right side
34·55000° C.	34·60555° C.	0	0·05555° C.	„	„ „
34·50000° C.	34·50000° C.	0	0	15	Equality
34·50000° C.	34·38889° C.	0·11111° C.	0	„	Left side
34·45000° C.	34·56111° C.	0	0·11111° C.	45	Right side
34·45000° C.	34·45000° C.	0	0	15	Equality
34·45000° C.	34·22778° C.	0·22222° C.	0	„	Left side
34·40000° C.	34·55000° C.	0	0·15000° C.	„	Right side
34·35000° C.	34·50000° C.	0	0·15000° C.	30	„ „
34·35000° C.	34·35000° C.	0	0	15	Equality
34·30000° C.	34·35555° C.	0	0·05555° C.	30	Right side
34·30000° C.	34·30000° C.	0	0	15	Equality
34·25000° C.	34·41666° C.	0	0·16666° C.	„	Right side
34·25000° C.	34·02778° C.	0·22222° C.	0	„	Left side
34·20000° C.	34·20000° C.	0	0	15	Equality
34·20000° C.	34·14445° C.	0·05555° C.	0	„	Left side
34·15000° C.	34·03889° C.	0·11111° C.	0	„	„ „
34·15000° C.	34·20555° C.	0	0·05555° C.	30	Right side
34·10000° C.	33·87778° C.	0·22222° C.	0	15	Left side
34·05000° C.	34·27222° C.	0	0·22222° C.	30	Right side
34·05000° C.	34·10555° C.	0	0·05555° C.	15	„ „
34·00000° C.	34·11111° C.	0	0·11111° C.	45	„ „
33·95000° C.	34·17222° C.	0	0·22222° C.	15	„ „
33·70000° C.	33·58889° C.	0·11111° C.	0	„	Left side
33·65000° C.	33·87222° C.	0	0·22222° C.	„	Right side
33·50000° C.	33·61111° C.	0	0·11111° C.	„	„ „
33·20000° C.	33·42222° C.	0	0·22222° C.	„	„ „

Analysis of Tables 1, 2, 3, and 4.

Comparison of percentages of frequency of occurrence of superiority of temperature of a side and of equality of temperature of the two sides.

(a) Cases where the higher of the two temperatures compared is 35° C., or above that point.

In favour of	Table 1 (1st Part). Number of Observations.	Table 1 (1st Part). Percentages.	Table 2 (1st Part). Number of Observations.	Table 2 (1st Part). Percentages.	Table 3 (1st Part.) Number of Observations.	Table 3 (1st Part.) Percentages.	Table 4 (1st Part). Number of Observations.	Table 4 (1st Part). Percentages.
Left side	135	20·9302	90	18·7500	120	11·7647	420	32·5582
Right side	315	48·8372	195	40·6250	690	67·6471	540	41·8604
Equality	195	30·2326	195	40·6250	210	20·5882	330	25·5814
Total	645		480		1020		1290	
Left and right sides alone . Left side	30·0000		31·5790		14·8148		43·7500	
Left and right sides alone . Right side	70·0000		68·4210		85·1852		56·2500	

(b) Cases where the higher of the two temperatures compared is below 35° C.

In favour of	Table 1 (2nd Part). Number of Observations.	Table 1 (2nd Part). Percentages.	Table 2 (2nd Part). Number of Observations.	Table 2 (2nd Part). Percentages.	Table 3 (2nd Part). Number of Observations.	Table 3 (2nd Part). Percentages.	Table 4 (2nd Part). Number of Observations.	Table 4 (2nd Part). Percentages.
Left side	210	32·5581	105	25·0000	120	19·0476	210	23·7288
Right side	255	39·5349	225	53·5710	435	69·0476	555	62·7118
Equality	180	27·9070	90	21·4290	75	11·9048	120	13·5594
Total	645		420		630		885	
Left and right sides alone . Left side	45·1620		31·8190		21·6216		27·4509	
Left and right sides alone . Right side	54·8380		68·1810		78·3784		72·5491	

Examining the above analysis, we arrive at the following conclusions for each table:

Table 1.

1st. The percentage of times of occurrence of superiority of temperature on the left side is greater at the *lower* of the two temperatures by 11·6279.

2nd. The percentage of times of occurrence of superiority of temperature on the right side is greater at the *higher* of the two temperatures by 9·3023.

3rd. The percentage of times of occurrence of equality of temperature of the two sides is greater at the *higher* of the two temperatures by 2·3256.

4th. Omitting the cases of equality of temperature, the left side gains and the right side loses 15·162 per cent., at the *lower* of the two temperatures.

Table 2.

1st. The percentage of times of occurrence of superiority of temperature on the left side is greater at the *lower* of the two temperatures by 6·250.

2nd. The percentage of times of occurrence of superiority of temperature on the right side is greater at the *lower* of the two temperatures by 12·946.

3rd. The percentage of times of occurrence of equality of temperature of the two sides is greater at the *higher* of the two temperatures by 19·196.

4th. Omitting the cases of equality of temperature, the two sides preserve very nearly the same percentages at the two temperatures, the left side gaining and the right side losing only 0·24 per cent., at the *lower* of the two temperatures.

TABLE 3.

1st. The percentage of times of occurrence of superiority of temperature on the left side is greater at the *lower* of the two temperatures by 7·2829.

2nd. The percentage of times of occurrence of superiority of temperature on the right side is greater at the *lower* of the two temperatures by 1·4005.

3rd. The percentage of times of occurrence of equality of temperature of the two sides is greater at the *higher* of the two temperatures by 8·6834.

4th. Omitting the cases of equality of temperature, the left side gains and the right side loses 6·8068 per cent. at the *lower* of the two temperatures.

TABLE 4.

1st. The percentage of times of occurrence of superiority of temperature on the left side is greater at the *higher* of the two temperatures by 8·8294.

2nd. The percentage of times of occurrence of superiority of temperature on the right side is greater at the *lower* of the two temperatures by 20·8514.

3rd. The percentage of times of occurrence of equality of temperature of the two sides is greater at the *higher* of the two temperatures by 12·022.

4th. Omitting the cases of equality of temperature, the left side loses and the right side gains 16·2991 per cent., at the *lower* of the two temperatures.

Comparing together the results obtained from the four tables given above, we find them to be, in a great measure, contradictory of each other. In only one respect do all four sets of observations agree, namely, in the existence of the greater percentage of equality of temperature at the higher

temperature. Tables 1, 2, and 3, agree in showing the greater percentage of superiority of temperature on the left side at the lower temperature; but in Table 4 the greater percentage of this condition is found, on the contrary, at the *higher* temperature. In Tables 2, 3, and 4, the greater percentage of superiority of temperature on the right side is found at the lower temperature; but in Table 1 the greater percentage of this condition occurs at the higher temperature. In Tables 1, 2, and 3, the percentage of left superiority increases, and that of right superiority diminishes, relatively to each other, at the lower temperature,* while in Table 4 the reverse occurs, right superiority gaining and left superiority losing, at the lower temperature.

In the following table the apportionment of the higher percentages of the three conditions to the two temperatures, in the four tables, is shown :

* In Table 2 the difference at the two temperatures is so slight that it may be disregarded.

		Temperatures of 35° C., and above. Percentages of excess.	Temperatures below 35° C. Percentages of excess.
Table 1.	Left side	0	11·6279
	Right „	9·3023	0
	Equality	2·3256	0
	Left and right sides alone.		
	Left side	0	15·162
	Right „	15·162	0
Table 2.	Left side	0	6·250
	Right „	0	12·946
	Equality	19·196	0
	Left and right sides alone.		
	Left side	0	0·24
	Right „	0·24	0
Table 3.	Left side	0	7·2829
	Right „	0	1·4005
	Equality	8·6834	0
	Left and right sides alone.		
	Left side	0	6·8068
	Right „	6·8068	0
Table 4.	Left side	8·8294	0
	Right „	0	20·8514
	Equality	12·022	0
	Left and right sides alone.		
	Left side	16·2991	0
	Right „	0	16·2991

No certain connection can, therefore, be traced in our tables, by the method of analysis pursued, between frequency of occurrence of superiority of temperature on either side, and the degree of absolute temperature of the parts examined; but a relation between absolute temperature and the frequency of occurrence of equality of temperature of the two sides would appear to exist, the greater percentage of equality being found at the higher absolute temperature.

Passing, in the next place, to the second of our two principal methods of analysis, namely, that which deals with the average absolute temperatures found with the conditions of right and left superiority of temperature and of equality of temperature, respectively, we obtain the following results from our tables:

Analysis of Tables 1, 2, 3, and 4.

Absolute temperatures.

A.—Cases where the higher of the two temperatures compared is 35° C. or above that point.

Table 1 (1st Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	35·50555°C.	35·41111°C.	0·18888°C.
Right side...	35·66066°C.	35·49136°C.	0·14940°C.
Equality	35·38846°C.		
			Both sides.
			0·16124°C.

Table 2 (1st Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	35·69166°C.	35·60729°C.	0·16875°C.
Right side...	35·67740°C.	35·60023°C.	0·15432°C.
Equality	35·61153°C.		
			Both sides.
			0·11215°C.

Extremes { Left side.....35·9°C. —35·0°C.....36·1°C. —35·0°C.
Right side .....36·125°C.—34·9°C.....36·325°C.—35·0°C.

Table 3 1st (Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	35·30625°C.	35·26614°C.	0·08020°C.
Right side...	35·38767°C.	35·32807°C.	0·11919°C.
Equality	35·34642°C.		
			Both sides.
			0·11342°C.

Table 4 (1st Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	35·67718°C.	35·60952°C.	0·09781°C.
Right side...	35·70451°C.	35·32100°C.	0·12812°C.
Equality	35·72500°C		
			Both sides.
			0·11564°C.

Extremes { Left side.....35·7°C. —34·9°C. .....36·4°C.—34·9°C.
Right side .....35·777°C·—34·93°C.....36·4°C.—34·888°C.

Analysis of Tables 1, 2, 3, and 4.

Absolute temperatures.

B.—Cases where the higher of the two temperatures compared is below 35° C.

Table 1 (2nd Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	34·41428°C.	34·29794°C.	0·22195°C.
Right side...	34·43874°C.	34·33555°C.	0·20933°C.
Equality	34·46250°C.		
			Both sides.
			0·21503°C.

Extremes { Left side.....34·9°C. —33·1°C.
Right side .....34·975°C.—33·025°C.

Table 2 (2nd Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	34·25714°C.	34·15446°C.	0·20535°C.
Right side...	34·43508°C.	34·34170°C.	0·18674°C.
Equality	34·30416°C.		
			Both sides.
			0·19266°C.

Extremes { Left side.....34·9°C. —33·10°C.
Right side .....34·975°C.—32·875°C.

Table 3 (2nd Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	34·61250°C.	34·56041°C.	0·10416°C.
Right side...	34·69188°C.	34·61404°C.	0·15564°C.
Equality	34·81000°C.		
			Both sides.
			0·14451°C.

Extremes { Left side.....34·9°C. —33·8°C.
Right side .....34·977°C.—34·105°C.

Table 4 (2nd Part).

	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	34·47857°C.	34·40913°C.	0·13888°C.
Right side...	34·47882°C.	34·41644°C.	0·12477°C.
Equality	34·51250°C.		
			Both sides.
			0·12864°C.

Extremes { Left side.....34·9°C. —33·2°C.
Right side .....34·988°C.—33·422°C.

Analysis of Tables 1, 2, 3, and 4.

Absolute temperatures.

c.—Both sets of cases—those at or above and those below 35° C.—taken together.

Table 1 (1st and 2nd Parts).				Table 2 (1st and 2nd Parts).		
	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.	Average temperature of cases of superiority of temperature of a side and of equality of temperature.	Average temperature of both sides taken together in the cases of superiority of a side.	Average differences of temperature.
Left side.....	34·84130°C.	34·73353°C.	0·22206°C.	34·91923°C.	34·78846°C.	0·18846°C.
Right side ..	35·06174°C.	34·97429°C.	0·17884°C.	35·01187°C.	34·92602°C.	0·17169°C.
Equality	34·94400°C.			35·19868°C.		
			Both sides. 0·19508°C.			Both sides. 0·17701°C.
Extremes { Left side	35·9°C.	—33·1°C.		36·1°C.	—33·10°C.	
Extremes { Right side	36·125°C.	—33·025°C.		36·325°C.	—32·875°C.	

Table 3 (1st and 2nd Parts).				Table 4 (1st and 2nd Parts).		
Left side.....	34·95937°C.	34·91328°C.	0·09218°C.	35·27764°C.	35·20939°C.	0·11269°C.
Right side...	35·11863°C.	35·05319°C.	0·13291°C.	35·08327°C.	34·86252°C.	0·12642°C.
Equality	35·20526°C.			35·40166°C.		
			Both sides. 0 12606°C.			Both sides. 0·12141°C.
Extremes { Left side	35·7°C.	—33·8°C.		36·4°C.	—33·2°C.	
Extremes { Right side	35·777°C.	—34·105°C.		36·4°C.	—33·422°C.	

From the above analyses we deduce the following conclusions:

(A) Cases where the higher of the two temperatures compared is 35° C., or above that point.

1st. Where the absolute temperature of the side only which in each comparison shows the higher temperature, and also the absolute temperature of the two sides in cases of equality of temperature are regarded, the apportionment in each table of the highest average absolute temperatures is as follows:

["1st" signifies highest average absolute temperature, and "2nd" and "3rd" correspond respectively to lower averages.]

Table 1.	Table 2.
1st. Right side.	1st. Left side.
2nd. Left side.	2nd. Right side.
3rd. Equality.	3rd. Equality.

Table 3.	Table 4.
1st. Right side.	1st. Equality.
2nd. Equality.	2nd. Right side.
3rd. Left side.	3rd. Left side.

2nd. Where the absolute temperatures of both sides are averaged in each case of superiority of a side, the absolute temperature in cases of equality being taken as before, the apportionment in each table of the highest average absolute temperatures is as follows:

Table 1.	Table 2.
1st. Right side.	1st. Equality.
2nd. Left side.	2nd. Left side.
3rd. Equality.	3rd. Right side.

Table 3.	Table 4.
1st. Equality.	1st. Equality.
2nd. Right side.	2nd. Left side.
3rd. Left side.	3rd. Right side.

(B) Cases where the higher of the two temperatures compared is below 35° C.

1st. Where the absolute temperature of the side only which in each comparison shows the higher temperature, and also the absolute temperature of the two sides in cases of equality of temperature are regarded, the apportionment in each table of the highest average absolute temperatures is as follows:

Table 1.	Table 2.
1st. Equality.	1st. Right side.
2nd. Right side.	2nd. Equality.
3rd. Left side.	3rd. Left side.

Table 3.	Table 4.
1st. Equality.	1st. Equality.
2nd. Right side.	2nd. Right side.
3rd. Left side.	3rd. Left side.

2nd. Where the absolute temperatures of both sides are averaged in each case of superiority of a side, the absolute temperature in cases of equality being taken as before, the apportionment in each table of the highest average absolute temperatures is as follows:

Table 1.	Table 2.
1st. Equality.	1st. Right side.
2nd. Right side.	2nd. Equality.
3rd. Left side.	3rd. Left side.

Table 3.	Table 4.
1st. Equality.	1st. Equality.
2nd. Right side.	2nd. Right side.
3rd. Left side.	3rd. Left side.

(C) Both sets of cases—those at and above 35° C., and those below that point—taken together.

1st. Where the absolute temperature of the side only which in each comparison shows the higher temperature, and also the absolute temperature of the two sides in cases

of equality of temperature are regarded, the apportionment in each table of the highest average absolute temperatures is as follows :

Table 1.	Table 2.
1st. Right side.	1st. Equality.
2nd. Equality.	2nd. Right side.
3rd. Left side.	3rd. Left side.
Table 3.	**Table 4.**
1st. Equality.	1st. Equality.
2nd. Right side.	2nd. Left side.
3rd. Left side.	3rd. Right side.

2nd. Where the absolute temperatures of both sides are averaged in each case of superiority of a side, the absolute temperature in cases of equality being taken as before, the apportionment in each table of the highest average absolute temperatures is as follows .

Table 1.	Table 2.
1st. Right side.	1st. Equality.
2nd. Equality.	2nd. Right side.
3rd. Left side.	3rd. Left side.
Table 3.	**Table 4.**
1st. Equality.	1st. Equality.
2nd. Right side.	2nd. Left side.
3rd. Left side.	3rd. Right side.

Comparing the above results, we find here, as in the case of our first method of analysis, marked contradictions in the different sets of experiments. Under the heading (A) we find in the first of its subdivisions that Tables 1 and 3 agree in showing the highest average absolute temperature in favour of superiority of temperature of the right side, but here all similarity between the two ends, for the order of precedence of superiority on the left side and of equality is the opposite in the two cases. Table 2 shows the left side to have the highest average, and equality to have the lowest average, while Table 4 shows an order exactly the reverse.

In the second subdivision of (A) Tables 2, 3, and 4 agree in giving the highest average to equality; and Tables 2 and 4 further agree in giving the lowest average to the right side; but in Table 1 the right side holds the first place and equality comes last. Coming to the heading (B) we find, in the first subdivision, Tables 1, 3, and 4 agreeing with each other, equality having the first and the left side the last place in all three cases; but in Table 2 the right side comes first, the left side coming last, as before. In the second subdivision of (B) Tables 1, 3, and 4 also agree, with the same order as above; Table 2 having likewise the same order that it had in the first subdivision. Lastly, under the heading (C) in the first subdivision, Tables 2 and 3 agree, equality holding the first and the left side the last place. Table 4 also gives the first place to equality, but the last to the right side; while in Table 1 the right side comes first and the left side last. In the second subdivision of this heading the order in the several tables is the same as in the first subdivision.

In the whole twenty-four sets (eight under each heading) equality holds the first place in sixteen, or two thirds; while in the remaining eight cases the right side comes first in seven cases. In seventeen cases the left side shows the lowest average, the right side coming last in four, and equality coming last in three cases.

It would seem, however, that the division of each table into two great parts, according as the temperature is above or below 35° C., and the consequent separate analyses of these two parts under the headings (A) and (B), are less likely to furnish accurate information on the points under consideration than the analysis of the two parts of each table taken together, as under the heading (C). The reason of this is that, in the analysis of the separate parts, the lower values, in the case of the first part of the table, and the higher values, in the case of the second part of a table, are on debatable ground, not being near either the upper or the lower limits. The absolute values included in the comparisons are, therefore, comprised, in the one instance, between the mean level and the upper limit of temperature, and, in the other instance, between the mean level and the

lower limit of temperature, and not between the two extremes. As a result of this artificial division of the observations, if a given condition—equality, for instance—happen to be of frequent occurrence about the mean level, the conclusions respecting this condition may be contradictory in the two parts of a table. In the first part the condition may show relatively a low, and in the second part relatively a high, average absolute temperature. This is shown, in point of fact, in Table 1, where equality exhibits in the first part the lowest and in the second part the highest average absolute temperature. But if, in consequence of the above objections, we regard only the results of the combined two parts of each table, we still find it impossible to reconcile the contradictions obtained. Tables 2, 3, and 4 give the highest average absolute temperature to equality, but Table 1 gives the precedence to the right side, equality holding the second place. Now, if the differences between the temperature of equality and the temperatures of right superiority in Table 1 were insignificant compared with the similar differences existing in the other tables, where equality holds the first place, we might be tempted to regard it as a rule that the highest average absolute temperatures are associated with equality. Let us see what these differences are. The differences in Table 1 between the temperature of equality and that of right superiority in the two sets of values in the table are, respectively, 0·11774° C. and 0·03029° C. The differences between equality and the condition holding the second place in the other three tables are as follows :—Table 2. —0·18681° C. and 0·27266° C. ; Table 3.—0·08663° C. and 015207° C. ; Table 4.—0·12402° C. and 0·19227° C.

The results might, indeed, lead us to ignore as unimportant one of the differences of Table 1, that of 0·03029° C. ; but the other difference is too marked to be set aside. Moreover, this latter figure is the more important of the two, as it belongs to the set of values representing the absolute temperature of the side alone on which superiority of temperature exists, whereas the first difference belongs to the set of values which represent the average temperature of both sides taken together in each comparison, and which, therefore, do not fairly represent the extreme height to which

the absolute temperature may rise in the case of superiority of temperature on a side.

If, on the other hand, we look to the lowest averages, we find that in three of the tables the left side holds the lowest place, the right side coming last in one table. Applying the same test in this case which was applied above, let us see if the differences of temperature between the values for the right side and those for the left side in Table 4 can be neglected, thus establishing a rule of the coincidence of the lowest average absolute temperature with superiority of temperature on the left side. The differences between the two lowest values in the several tables are as follows :—Table 1. —0·10270° C. and 0·21047° C.; Table 2.—0·09264° C. and 0·13756° C.; Table 3.—0·15926° C. and 0·13991° C.; Table 4. —0·19437° C. and 0·34687° C. Looking at these figures, it is, of course, impossible to ignore the differences shown in Table 4.

We are thus finally forced to choose between concluding that no one of the three conditions of superiority of the right side, superiority of the left side, and equality of the two sides respectively, exhibits a definite and fixed preference for a higher or lower absolute level than the others, or the rejection of some of our tables and the exclusive acceptance of others. There is not, however, the slightest justification of this latter course to be found, for the observations of the several tables were made with the same care and under equally favorable conditions, and are, therefore, equally reliable. And in this connection we see the value of the accidental division into the four tables of the entire mass of observations, due, as it was, simply to the fact of there being four distinct periods of investigation. Moreover, each table contains a sufficient number of observations to preclude its rejection in favour of another on the score of numerical inferiority.

The result, then, of our two principal methods of analysis has been to furnish but a single satisfactory conclusion, the one derived from the first method and already given on page 21, namely, that the percentage of frequency of occurrence of equality of temperature is greater at temperatures at or above 35° C. than at temperatures below that point. If we

relied solely on Table 4, we might consider it as further proved (in accordance with the theory mentioned at the outset on page 4) that superiority of temperature on the left side is relatively more frequent at the higher than at the lower levels of absolute temperature, while superiority of temperature on the right side is relatively more frequent at the lower than at the higher levels ; but, as just stated, we have no right to adopt the results of one table to the exclusion of those of another.

There are, however, certain points in our tables which have not come within the scope of our two methods, which demand attention.

If we examine the tables near the upper and lower limits, we see that the extent of range is not equal in all the tables. Taking, on the one hand, only those observations in which the higher of the two temperatures is at or above 36° C., and, on the other hand, only those observations in which the higher of the two temperatures is below 34° C., we find at the start that Table 3 is excluded from any examination based upon such limitations, and that Table 1 furnishes but fifteen observations falling within the upper limit.

Analysing the observations in the several tables included in the limits specified, we obtain the following results :

(D) *Temperatures at or above 36° C.*

	Table 1.		Table 2.		Table 4.	
In favour of	Number of observations.	Percentages.	Number of observations.	Percentages.	Number of observations.	Percentages.
Left side.....	0	0	15	20·0000	105	41·17647
Right side ...	15	100·0000	45	60·0000	45	17·64706
Equality.....	0	0	15	20·0000	105	41·17647
Total...	15		75		255	

(E) *Temperatures below 34° C.*

	Table 1.		Table 2.		Table 4.	
Left side.....	15	25·0000	15	25·0000	15	25·0000
Right side	45	75·0000	30	50·0000	45	75·0000
Equality.....	0	0	15	25·0000	0	0
Total...	60		60		60	

In the above sets of results we again encounter contradictions. Part of Table 1 is of doubtful value, owing to the limited number of observations made at the higher temperature. Omitting this part of the table, and regarding only the part under the heading (E), we find a total absence of equality and a decided predominance of right superiority of temperature. If we refer to the same table in the former comparison of percentages on page 21, we see how marked this excess in favour of the right side is. Table 2, however, shows a decided balance in favour of the right side at the higher temperature, the percentages for the left side and for equality being each one third of that for the right side; while at the lower temperature the percentage for the right side diminishes, and the percentages for the left side and for equality increase. In Table 4, on the contrary, at the higher temperature right superiority shows the smallest percentage, left superiority and equality having here the same percentage, which is more than twice that for the right side; still further, at the lower temperature in this table equality is absent and right superiority is greatly in excess of left superiority.

If we take the individual observations within these last limits, we find that the highest absolute temperature noted, 36·4° C. (Table 4), accompanies equality; the second highest temperature, 36·325° C. (Table 2), accompanies right superiority; and the third highest temperature, 36·3° C. (Table 4), is found with left superiority. The lowest case of superiority of a side, 33·1° C., and which occurs twice, is in favour of the left side (Tables 1 and 2); the second lowest case, 33·25° C. (Table 2), is in favour of the right side; and the third lowest case, 33·325° C. (Table 1), is also in favour of the right side.

We will now make another and last analysis, embracing, on the one hand, those cases in which the higher of the two temperatures compared is not below 35·5° C., and, on the other hand, those cases in which the higher of the two temperatures compared is not above 34·55° C.

The following are the results obtained by this last analysis:

Analysis of Tables 1, 2, 3, and 4.

Comparison of percentages of frequency of occurrence of superiority of temperature of a side and of equality of temperature of the two sides.

(f) Cases where the higher of the two temperatures compared is not below 35·5° C.

In favour of	Table 1. Number of Observations.	Table 1. Percentages.	Table 2. Number of Observations.	Table 2. Percentages.	Table 3. Number of Observations.	Table 3. Percentages.	Table 4. Number of Observations.	Table 4. Percentages.
Left side	90	28·5715	75	22·7273	15	6·2500	300	31·2500
Right side	165	52·3809	120	36·3636	180	75·0000	420	43·7500
Equality	60	19·0476	135	40·9091	45	18·7500	240	25·0000
Total	315		330		240		960	

(g) Cases where the higher of the two temperatures compared is not above 34·55° C.

Left side	105	26·9231	60	25·0000	45	23·0769	105	23·3334
Right side	165	42·3077	120	50·0000	150	76·9231	270	60·0000
Equality	120	30·7692	60	25·0000	0	0	75	16·6666
Total	390		240		195		450	

No satisfactory conclusions can be drawn from the above analysis. In two of the tables (Tables 1 and 4) the percentage for superiority of the left side diminishes at the lower temperature, while in the other two tables it increases at this temperature. In Table 1 the percentage for superiority of the right side is greater at the higher temperature, while in the other three tables it is greater at the lower temperature. In one case (Table 1) equality of temperature shows an increase at the lower temperature; but in Tables 2 and 4 the percentage of this condition is diminished, and in Table 3 no case of equality is found at the lower temperature.

Summing up the results of all our analyses, it would seem that the degree of absolute temperature has no definite influence on the frequency of occurrence of superiority of temperature on either side of the head, and but a limited influence, at best, on equality of temperature of the two sides; at every absolute level each of the three conditions may be found with varying frequency at different times.

It would, seem, therefore, that the rises and falls of absolute temperature, by which the balance of superiority of temperature is shifted from one side to the other, or by which equality of temperature of the two sides is brought about, follow, in a great measure, no definite law, but are governed by agencies which are liable to constant variation. The two sides are not, then, like two furnaces which have unequal limits of range, but in which the production of heat is carefully controlled so as to cause simultaneously in both regular increases or diminutions of energy, one surpassing or falling below the other only at certain fixed points, and then simply because the thermal limit of one has been reached; but they rather resemble two furnaces of equal range, but the fires of which are, to a certain extent, managed independently of each other and with a variable degree of regularity, the relative powers of the two being thus uncertain, and either one likely at any moment to surpass the other.

There is one other point to be noticed in conclusion, namely, the comparative degree of difference of temperature between the two sides of the head at different absolute levels. Looking back to the analysis of absolute tempera-

tures on page 26, we see that, with one exception, the average degree of difference of temperature between the two sides is greater at the temperatures below 35° C. The single exception is in Table 4, where the average difference of temperature in the cases in favour of the right side is slightly less at the lower temperature. As the absolute level rises, therefore, the average difference between the two sides would seem to diminish; but a glance at the tables will show many exceptions to this rule, the irregular and unequal rises and falls of the temperatures of the two parts bringing about as great differences even near the extreme limit as those shown at the lower levels.

The causes of these irregularities are undoubtedly many and complicated, some existing in the brain and some in the tissues external to the latter. The writer has elsewhere dealt to a certain extent with some of these causes, and it suffices to say now that their existence and unmanageable nature must throw grave doubts on the reliability of conclusions drawn from examinations of the temperature of the head in disease, unless much greater latitude be given to normal variations of temperature, both absolute and relative, than has generally been accorded by those who have given special attention to this subject.

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EXPERIMENTS

ON THE EFFECT OF

VOLUNTARY MUSCULAR CONTRACTIONS

ON THE

TEMPERATURE OF THE HEAD.

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EXPERIMENTS

ON THE EFFECT OF

VOLUNTARY MUSCULAR CONTRACTIONS

ON THE

TEMPERATURE OF THE HEAD.

In the spring of the present year, Dr. R. W. Amidon, of New York, published a series of experiments entitled, "The Effect of Willed Muscular Movements on the Temperature of the Head: New Study of Cerebral Cortical Localisation." * By these experiments the author sought to prove, not only that willed muscular movements cause elevations of temperature at the surface of the head, sufficiently marked to be capable of detection with thermometers, but also, that the contractions of different muscles affect the temperatures of different well-defined areas of the integument of the head; each muscle —according to him—having a special thermal centre in the cortical substance of the brain, the temperature of which centre is increased, when the muscle acts, in a degree sufficient—both absolutely, and relatively to the rest of the cerebral surface—to produce a change of temperature, in a circumscribed area of the overlying integument, appreciable by means of instruments of no great delicacy. Thus contraction of the quadriceps extensor cruris of one side caused an average rise of 0·409° C., on the opposite side of the head,

* Prize Essay of the Alumni Association of the College of Physicians and Surgeons of New York, March 12th, 1880; published in 'Archives of Medicine,' April, 1880; also published separately by G. P. Putnam's Sons, New York.

in a space commencing 300 mm. behind the root of the nose, and extending backwards, on the median line, 80 mm., and laterally, from the same line, 50 mm.,—the extremes of rise of temperature being 1·388° C., and 0·1388° C.; * while contraction of the orbicularis palpebrarum of one side produced a rise averaging 0·342° C. (the extremes were 0·833° C., and 0·1388° C.), on the opposite side of the head, in a space situated about 100 mm. above, and a little to the rear of the external auditory meatus, and having a diameter of about 18 mm.

Dr. Amidon's method of procedure was as follows:—A number of thermometers (Seguin's surface thermometer, as improved by Dr. Gray, of Brooklyn, was employed) were placed at different points on the head, and secured to the latter by means of a quadrilateral piece of sheet rubber with straps and buckles at the corners, the rubber being pierced with holes for the passage of the stems of the instruments.

After ten or fifteen minutes of quiet, the readings of the thermometers were taken, and the subject then commenced to make vigorous contractions of some particular muscle or group of muscles (tonic and clonic spasms alternating produced the best results) for from five to ten minutes. At the end of five minutes from the cessation of the contractions the readings of the thermometers were again noted. "If a marked rise of temperature is noticed in any one of them, the other thermometers must be brought together and concentrated about this spot so as to define the area over which the rise of temperature takes place as narrowly as possible." Proceeding in this way, Dr. Amidon mapped out some twenty-five districts on the surface of the head, as thermal centres of a corresponding number of muscles or groups of muscles.

As long ago as 1866-67, one of the writers of the present paper (Lombard), while experimenting with thermo-electric apparatus on the influence of different mental states on the human temperature, was led to try the effect of muscular contraction on the temperature of the head. In doing this

* Dr. Amidon's values are given in Fahrenheit degrees, hence the extended decimals given above and in other places.

he had no idea of a production of heat in the brain, specially connected with the muscular contraction *per se;* the muscular effort was made use of *simply as a means of strongly fixing the attention.* In the majority of these cases no effect was produced; but in a few instances, slight rises of temperature were noted—0 005° C. to 0·02° C. It was found, moreover, that simply holding up a finger between the eye and an object regarded intently, at a little distance, and moving the finger at regular intervals to one side and back again, so as, in turn, to cover and uncover the object—pains being taken to move the finger to the same distance each time, and to accurately cover the object at each return—was more effective in causing a rise of temperature in the head, than strong contractions of the muscles of the arm or of the leg. At a more recent date (1877) the same person having occasion, in further experiments on the influence of mental activity on the temperature of the head, to study the effect of composition, thought it desirable to eliminate any possible disturbance arising from the muscular action concerned in the writing. It was found, however, that the mere mechanical movements of the pen were without effect.

In the investigations now to be given all the essential experimental details laid down by Dr. Amidon have been carefully observed; thermo-electric apparatus, however, has been substituted for thermometers, both as being far more sensitive, and also as enabling the observer to detect the slightest variation of temperature at any moment of the experiment. The particular apparatus employed has been fully described elsewhere.*

In the experiments "zero" denotes the temperature of the head at the commencement of the observations, and the "plus" and "minus" signs denote, respectively, rises above, and falls below this initial point. Where the words "stopped contractions" occur, they refer to the time *immediately preceding* them; for example, in 1st experiment on contraction of extensors of leg, &c., the contractions were stopped at the end of the tenth minute. Other words put

* J. S. Lombard, 'Experimental Researches on the Regional Temperature of the Head,' London, 1879. Idem, 'Archives de Physiologie Normale et Pathologique,' July—August, 1868, t. i, p. 498.

in the margin refer to the times opposite to which they are placed. The experiments were all made on the writers themselves.

Experiments on the contraction (simultaneously) of the extensor muscles of the leg and of the toes (quadriceps extensor cruris; and the extensors proper of the toes), and of the flexors of the tarsus upon the leg (tibialis anticus, and peroneus tertius). The thermo-pile was applied at points varying from 310 mm's. *to* 370 mm's. *distance from the root of the nose, measured on the median line, and from* 10 mm's. *to* 40 mm's. *distance laterally from the same line. The pile was on the left side of the head, and the muscles of the right side were contracted.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
3 „	— 5°	—0·0208°C.	
5 „	—10°	—0·0416°C.	
6 „	— 8°	—0·0333°C.	
7 „	— 4°	—0·0166°C.	
8 „	— „	— „	
9½ „	— „	— „	
10 „	— 3°	—0·0124°C.	
			Stopped contractions.
12 „	—10°	—0·0416°C.	
14 „	—50°	—0·2083°C.	
15 „	—20°	—0·0833°C.	

In the above experiment, the temperature, at the end of the third minute succeeding the commencement of the contractions, had fallen 0·0208° C. below the starting point. During the remaining seven minutes of contractions it fluctuated between 0·0416° C., and 0·0124° C., both values being below the initial temperature. After the cessation of the contractions, the temperature fell still lower, being 0·2083° C. below the starting point, at the fourth minute,

and 0·0833° C. below this point at the close of the observation five minutes after the cessation of the contractions, and fifteen minutes from the commencement of the experiment. In this experiment, therefore, there was throughout a *depression* of temperature. It is not, however, probable that the muscular movements had much to do with the principal fall of temperature noted towards the close of the experiment. There was undoubtedly a tendency in the head toward a *lower thermal level,* irrespective of any special influence connected with the experiment. These falls of temperature—with corresponding rises—are of frequent occurrence in the head, and if not carefully watched, and duly accounted for, are apt to lead the experimenter to very erroneous conclusions. They are most probably seated in tissues external to the brain—notably the integument—and have, therefore, no *immediate* connection with cerebral action. Their causes are in many, if not in most cases, obscure; for while some may be accounted for by changes of the temperature of the air, alterations of the general circulation, &c., in a large number of instances these influences afford no explanation.

2nd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
3 „	+ 8°	+ 0·0333°C.	
4 „	+ 15°	+ 0·0625°C.	
6 „	— 5°	— 0·0208°C.	
7 „	— „	— „	
10 „	— 18°	— 0·0750°C.	
			Stopped contractions.
15 „	0°	0°	
16 „	+ 1°	+ 0·00416°C.	

We have here, at first, a rise of temperature amounting, at the end of four minutes, to 0·0625° C. But in the succeeding two minutes a fall ensued to 0·0208° C. below the

starting point. At the end of the tenth minute—when the contractions were stopped—this fall had increased to 0·075° C. below the initial temperature. During five minutes succeeding the close of the contractions the initial temperature was regained, and finally, at the end of the sixteenth minute, a positive rise of 0·00416° C. had taken place. In this experiment there was, therefore, during the contractions, on the one hand, a positive rise of 0·0625° C., and, on the other hand, a positive fall of 0·075° C.

3rd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
3 „	— 3°	—0·0124°C.	
6 „	0°	0°	
8 „	—11°	—0·0458°C.	
9 „	+ 1°	+0·00416°C.	
10 „	— 1°	—0·00416°C.	
			Stopped contractions.
13 „	+10°	+0·0416°C.	
14 „	+ 5°	+0·0208°C.	
15 „	+ „	+ „	

In this experiment the temperature, at first, fell 0·0124° C.; then rose to the starting point, but fell back, at the eighth minute, to 0·0458° C. below the zero. At the ninth minute, it had again attained the starting point, and had passed 0·00416° C. above the latter; but at the tenth, and last, minute of contraction, it had fallen 0·00416° C. below the starting point. Three minutes after the contractions ceased there was a positive rise of 0·0416° C.,—which was, however, reduced to 0·0208° C. in the two minutes following. We have here, then, a maximum rise of 0·0416° C., and a maximum fall of 0·0458° C.

4th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
3 „	—11°	—0·0458°C.	
4 „	0°	0°	
5 „	+ 1°	+ 0·00416°C.	
6 „	— 1°	—0·00416°C.	
7 „	— 2°	—0·0083°C.	
			Stopped contractions.
8 „	0°	0°	
9 „	+ 4°	+ 0·0166°C.	
10 „	+ 6°	+ 0·0250°C.	
11 „	+ „	+ „	
12 „	+ 4°	+ 0·0166°C.	

In the above experiment, after the contractions commenced, the temperature fell, reaching, at the end of three minutes, a point 0·0458° C. below the zero. It regained the latter point, however, during the next minute, and at the end of the fifth minute indicated 0·00416° C. positive rise. At the end of the seventh minute—when the contractions were stopped—the temperature had fallen back to 0·0083° C. below the zero. During the five minutes following the close of the contractions, the temperature again regained the starting point, and passed 0·025° C. above it (tenth and eleventh minutes).

Maximum rise	0·00416°C.	During contractions.
„ fall	0·0458°C.	During contractions.
„ rise	0·025°C.	After „

5th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
7 „	— 4°	—0·0344°C.	
10 „	—16°	—0·1376°C.	
			Stopped contractions.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
11, 12, 13, 14, 15, 16 minutes	—20°	—0·1720°C.	Temperature oscillating.
	—16°	—0·1376°C.	
	—12°	—0·1032°C.	

In this experiment, after seven minutes' contractions, the temperature had fallen 0·0344° C.; and when the contractions ceased, at the end of the tenth minute, this fall had increased to 0·1376° C. During six minutes' succeeding the close of the contractions, the temperature fluctuated, being successively 0·172° C., 0·1376° C., and 0·1032° C.—all below the starting part. A part of the fall, when at its greatest, is, however, probably explainable in the same way as the fall in 1st Experiment, and is, therefore, independent of the muscular action.

6th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
2 „	+4°	+0·0344°C.	
3 „	0°	0°	
6 „	—2°	—0·0172°C.	
			Stopped contractions.
13 „	—„	— „	

In this experiment the temperature rose, in the first two minutes, 0·0344° C.; but in the next minute it declined to zero, and at the close of the contractions it was 0·0172° C. below that point, maintaining this latter position at the end of the experiment.

7th Experiment.

1° deflection of galvanometer is equal to 0·007539°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „			
2 „	—5°	—0·0377°C.	Temperature oscillating.
3 „	0°	0°	
4 „	+5°	+0·0377°C.	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
5 minutes	0°.....	0°	
6 „	„	„	
7 „	„	„	
8 „	„	„	
8½ „	„	„	
			Stopped contractions.
13½ „	„	„	

We have here, during the first four minutes, an oscillation about the starting point as a centre, with a range below and above of 0·0377° C.; and subsequently, during the remaining five and a half minutes of contractions, and for five minutes of repose afterwards, a maintenance of the initial temperature.

8th Experiment.

1° deflection of galvanometer is equal to 0·007539°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6 minutes	„	„	
7 minutes	—2°.....	—0·0150°C.	
8, 9, 10 minutes	0°.....	0°	
			Stopped contractions.
11, 12, 13, 14, 15, 16 minutes.....	„	„	

In this experiment for the first six minutes no change of temperature occurred. At the end of the seventh minute a fall of 0·015° C. was noted. From this time forth, to the end of the experiment, the initial temperature was maintained.

9th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1 „	„	„	
2 „	„	„	
3 „	„	„	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
4 minutes	+6°	+0·0516°C.	
5 „	+„	+„	
6 „	0°	0°	
7 „	—4°	—0·0344°C.	
			Stopped contractions.
8, 9, 10, 11, 12, 13, 14 minutes	—7°	—0·0602°C.	Temperature oscillating.
	—4°	—0·0344°C.	
	—1°	—0·0086°C.	

Here we have, first, during three minutes, the initial temperature maintained; then a rise of 0·0516° C., preserved during the fourth and fifth minutes; then a return to zero, with a subsequent fall of 0·0344° C. below that point. During seven minutes after the contractions ceased the temperature fluctuated, being, in turn, 0·0602° C., 0·0344° C., and 0·0086° C., below the starting point.

10th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7, 7½ minutes	—5°	—0·043°C.	Temperature oscillating.
	0°	0°	
	+3°	+0·0258°C.	
			Stopped contractions.
8, 9, 10, 11, 12, 13, 14, 15, 15½ minutes	—5°	—0·043°C.	Temperature oscillating.
	0°	0°	
	+3°	+0·0258°C.	

In this experiment, during seven and a half minute's contractions, the temperature oscillated on both sides of zero, with a range of 0·043° C. below, and of 0·0258° C. above that point, this oscillation continuing during eight and a half minutes following the cessation of the contractions.

11th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
½ „	+6°	+0·0516°C.	
1 and 2½ minutes	—4°	—0·0344°C.	
3, 4, 5, 6, 7, 8, 9, 10 minutes	—9°	—0·0774°C.	Temperature oscillating.
	—4°	—0·0344°C.	
	+1°	+0·0086°C.	
			Stopped contractions.
11, 12, 13, 14, 15, 16, 17, 18 minutes	—9°	—0·0774°C.	Temperature oscillating.
	—4°	—0·0344°C.	
	+1°	+0·0086°C.	

In this experiment, after a rise in the first half minute of 0·0516° C., the temperature declined to 0·0344° C. below the starting point, subsequently fluctuating between 0·0774° C. below, and 0·0086° C. above the zero, during the remaining seven and a half minutes of contractions, and also during the eight minutes of repose which followed.

12th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	+5°	+0·0430°C.	
2, 3, 4, 5 minutes	+„	+„	
6 minutes	+3°	+0·0258°C.	
7, 8, 9, 10 minutes	+„	+„	
			Stopped contractions.
11, 12, 13, 14, 15, 16 minutes	+„	+„	

In the above experiment the temperature rose during the first minute 0·043° C., and maintained this elevation to the end of the fifth minute, when it fell back to 0·0258° C. above the starting point, retaining this position during the remaining minutes of contraction, and for six minutes of repose following.

13th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	−2°	−0·0172°C.	Temperature oscillating.
	0°	0°	
	+2°	+0·0172°C.	
			Stopped contractions.
11 minutes	−5°	−0·0430°C.	
12 „	0°	0°	

We have here, during the time of the contractions, an oscillation about the starting point of 0·0172° C. above and below the latter. At the end of the fourth minute after the contractions ceased, the temperature had fallen to 0·043° C. below the zero. Finally, at the close of the experiment, at the end of the twelfth minute from the commencement of the observations, the temperature was at the starting point.

14th Experiment.

1° deflection of galvanometer is equal to 0·008602°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7, 8 minutes	−7°	−0·0602°C.	Temperature oscillating.
	0°	0°	
	+4°	+0·0344°C.	
			Stopped contractions.
9, 10, 11, 12, 13, 14 minutes	−7°	−0·0602°C.	Temperature oscillating.
	0°	0°	
	+4°	+0·0344°C.	

In this case, during the eight minutes of contractions, the temperature oscillated about the starting point with a range of 0·0602° C. below, and of 0·0344° C. above the latter. This oscillation persisted during the six minutes following the close of the muscular action.

15th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
3 „	— 60°	—0·2500°C.	
5 „	—100°	—0·4166°C.	
6 „	—110°	—0·4583°C.	
8 „	—150°	—0·6250°C.	
10 „	—180°	—0·7500°C.	
			Stopped contractions.
15 „	—353°	—1·4708°C.	

In this experiment, we have a decided and continuous fall of temperature from the commencement to the end of the observations; the fall at the close of the experiment amounting to 1·4708° C. This marked depression of temperature, like those given in 1st and 5th Experiments, was, however, beyond doubt, in a great measure independent of the experiment, its coincidence with the latter being simply accidental. This experiment, in fact, furnishes an excellent example of a rapid and decided lowering of the general level of temperature in the head, where no special cause of disturbance could be proved to exist.

16th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
4 „	— 85°	—0·3541°C.	
6 „	—100°	—0·4166°C.	
7 „	—155°	—0·6458°C.	
			Stopped contractions.
12 „	—358°	—1·4916°C.	

We have here again a decided and persistent fall of temperature during whole of the observation, probably explainable, in great part, like the results of the last experiment, by a lowering of the general level of temperature irrespective of the muscular action.

17th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
2 „	+ 10°	+0·0416°C.	
3 „	+ 45°	+0·1874°C.	
5 „	+115°	+0·4791°C.	
			Stopped contractions.
10 „	+ „	+ „	

This experiment shows a decided rise of temperature, setting out from the commencement of the observations, and amounting, at the end of the fifth minute—when the contractions were discontinued—to 0·4791° C. At the close of the experiment—at the end of the tenth minute—the temperature was still 0·4791° C. above the starting point. This was undoubtedly a case of *elevation* of the general thermal level—the opposite, in fact, of what occurred in the preceding two experiments.

18th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7, 7½ minutes	−5°	−0·0352°C.	Temperature oscillating.
	0°	0°	
	+2°	+0·0140°C.	
			Stopped contractions.
12½ minutes	+4°	+0·0281°C.	
13½ „	+5°	+0·0352°C.	

In this experiment the temperature of the head fluctuated during the seven and a half minutes of contractions, being, in turn, at 0°, and at 0·0352° C. below and 0·014° C. above that point. After the contractions ceased the temperature rose, attaining, at the end of twelve and a half minutes from the commencement of the experiment, 0·0281° C. above the

starting point, and rising still higher by 0·00704° C. in the succeeding minute.

19th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
4 „	+60°	+0·4225°C.	
			Stopped contractions.
9 „	+71°	+0·5000°C.	

In this experiment a marked and rapid rise of temperature ensued, amounting at the close of the experiment to 0·5° C. above the starting point. The comments made upon 17th Experiment are equally applicable to the present case.

20th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
12 minutes	—2°	0·014°C.	

In the above experiment the initial temperature remained unaffected during seven minutes' muscular action. During five minutes subsequent repose the temperature fell 0·014° C.

21st Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6 minutes	„	„	
7 minutes	—2°	—0·0140°C.	
			Stopped contractions.
8, 9, 10, 11, 12, 13½ minutes	—3°	—0·0211°C.	Temperature oscillating.
	0°	0°	
	+3°	+0·0211°C.	

In this case, for the first six minutes of contractions, the temperature was unaffected, but in the seventh minute a fall of 0·014° C. took place. During six and a half minutes' repose following the contractions the temperature fluctuated about the starting point, with an equal range above and below the latter of 0·0211° C.

22nd Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1,2,3,4,5,6,7,8 minutes	−4°	−0·0281°C.	Temperature oscillating.
	0°	0°	
	+4°	+0·0281°C.	
			Stopped contractions.
9, 10, 11, 12, 13, 14, 15, 16 minutes ...	−4°	−0·0281°C.	Temperature oscillating.
	0°	0°	
	+4°	+0·0281°C.	

In this experiment, during eight minutes' contractions, the temperature oscillated about the zero, with an equal range above and below this point of 0·0281° C. Eight minutes of repose, following the contractions, showed no change, the fluctuation continuing with the same limits as before.

23rd Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

24th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

25th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

26th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

27th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

28th Experiment.

1° deflection of galvanometer is equal to 0·0070422°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

29th Experiment.

1° deflection of galvanometer is equal to 0·0074022°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

30th Experiment.

1° deflection of galvanometer is equal to 0·0074022°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

31st Experiment.

1° deflection of galvanometer is equal to 0·0045°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature either during or after the contractions.

32nd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes.....	+0°	0°	Commenced contractions.
2 „	+100°.....	+0·4166°C.	
3 4, 5, 6, 7 minutes ...	+ „	+ „	
			Stopped contractions.

In this experiment the rise was probably in great part due to an elevation of the general thermal level, such as we have before considered in 17th and 19th Experiments. There was in this case no observation of the temperature after the close of the contractions.

We will now analyse the thirty-two experiments thus far given; and to this end, we will first divide them into eight classes, as follows, giving the numbers and percentages of cases belonging to each class, and also designating the particular experiments in which they are found:

	Number of cases.	Per-centages.	Where found. Experiments.
a. Cases of rise of temperature without fall	1 ...	3·125 ...	12th.
b. „ fall „ „ rise	2 ...	6·250 ...	8th and 20th.
c. „ rise of temperature counterbalanced by equal fall below starting point.....	4 ...	12·500 ...	7th, 18th, 21st, and 22nd.

	Number of cases.	Per-centages.	Where found. — Experiments.
d. Cases of rise and fall together, the fall being greater than the rise	8	25·000	2nd, 3rd, 4th, 9th 10th, 11th, 13th, and 14th.
e. „ rise and fall together, the rise being greater than the fall .	1	3·125	6th.
f. „ temperature remaining unchanged	9	28·125	23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, and 31st.
g. „ rise to higher general level ...	3	9·375	17th, 19th, and 32nd.
h. „ fall to lower general level ...	4	12·500	1st, 5th, 15th, and 16th.

Omitting the seven experiments attributed to change of thermal level, we have left twenty-five results, in fourteen of which a rise was—at some period—noted; although in all but two of these cases (12th and 6th Experiments), the rise was either counterbalanced or outweighed by a fall, and in one of the two (6th Experiment), the rise was immediately succeeded by a fall to the initial temperature, and subsequently to a point below the latter. We have, therefore, *only a single instance* that can fairly be adduced as evidence of a rise of temperature due to muscular contraction.* On the contrary, we have two cases of independent fall, and eight cases in which the fall was in excess of the accompanying rise.

Making a new table out of the twenty-five cases open to discussion, we have the following values:

	Number of cases.	Per-centages.
a. Cases in which a rise of temperature either existed independently or predominated	2	8
b. „ „ a fall of temperature either existed independently or predominated	10	40

* If the three experiments (17th, 19th, and 32nd) attributed to rise of general thermal level be taken into account as possibly connected, in any decided degree, with the muscular movements, we must, in justice, give an equally important place to 1st, 5th, 15th, and 16th experiments, in which the muscular exertion was accompanied by a *fall* of temperature. The two sets of cases would thus counterbalance each other.

	Number of cases.	Percentages.
c. Cases in which both a rise and a fall of equal extent existed	4	16
„ „ no change of temperature occurred	9	36

From the above figures it will be seen that the cases in which a *fall* of temperature predominated *were the most numerous.* Next in number come the cases where no change of temperature occurred, while the instances in which a *rise* predominated show *the smallest figure of all.*

Taking, in each of the fourteen experiments in which a rise occurred, the highest thermometric value attained (whether found during the contractions, or in the subsequent period of repose), we find the average greatest rise to be 0·03637°C.; the extremes being 0·0625° C., and 0·0172° C. In the fifteen cases in which a fall occurred, the average greatest fall was 0·04124° C., the extremes being 0·0774° C., and 0·014° C.

Of seventy-three experiments on the quadriceps extensor cruris (the most powerful of the muscles concerned in the experiments in hand) tabulated by Dr. Amidon,* thirty-seven showed a rise of temperature, twenty-three a fall of temperature, and in thirteen no change occurred. The percentages of the three conditions were, therefore, as follows:

Rise of temperature	50·6849 per cent.
Fall „	31·5068 „
Temperature unchanged	17·8083 „

The average rise of temperature in the thirty-seven cases in which this condition existed, was 0·40915° C., the extremes being 1·38875° C., and 0·13888° C.; these figures being, respectively, eleven, twenty-two, and eight times the corresponding values found by the writers.

* Op. cit., p. 38

Experiments on the contraction of the muscles of the calf. The thermo-pile was placed at a point distant from the root of the nose 290 mm. *on the median line, and distant laterally from this line* 25 mm. *The pile was on the left side of the head, and the muscles of the right side were contracted.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, minutes	„	„	
10 minutes	—7°	—0·0291°C.	
			Stopped contractions.
11, 12, 13, 14, 15, 16 minutes	—10°	—0·0416°C.	Temperature oscillating.
	— 7°	—0·0291°C.	
	— 4°	—0·0166°C.	

In this case during the first six minutes of muscular action the temperature was unaffected; at the end of the tenth minute, however, it had fallen 0·0291° C. below the starting point. During the six minutes of repose following it fluctuated, 0·0416° C., 0·0291° C., and 0·0166° C., all below the starting point, being noted.

2nd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	—5°	—0·0208°C.	Temperature oscillating.
	0°	0°	
	+ 5°	+ 0·0208°C.	
			Stopped contractions.
8, 9, 10, 11, 12 minutes	—5°	—0·0208°C.	Temperature oscillating.
	0°	0°	
	+ 5°	+ 0·0208°C.	

Oscillation about the starting point, with a range of 0·0208° C. above and below the latter, marked the seven minutes of contraction and the five minutes of subsequent repose of this experiment.

3rd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1,2,3,4,5,6,7 minutes	„	„	
			Stopped contractions.
8,9,10,11,12 „	„	„	

No change of temperature either during or after the contractions.

4th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1,2,3,4,5,6,7 minutes	„	„	
			Stopped contractions.
8,9,10,11,12 „	„	„	

No change of temperature either during or after the contractions.

We have, as the results of these four experiments, one case of fall of temperature (0·0416° C. at its greatest) (1st Experiment); one case of equal rise and fall, of 0·0208° C. (2nd Experiment); and two cases in which no change of temperature occurred (3rd and 4th Experiments).

Seventy-three experiments on these muscles, tabulated by Dr. Amidon,* give the following values:

	Number of cases.	Percentages.	
Rise of temperature	42 ...	57·5343 ...	Average rise, 0·37037°C.
Fall „	9 ...	12·3288 ...	Maximum „ 0·9722°C.
Temperature unchanged...	22 ...	30·1369 ...	Minimum „ 0·1388°C.

* Op. cit., p. 36.

Experiments on the contraction of the biceps of arm. The thermo-pile was placed at distances from the root of the nose, on the median line, varying from 180 mm. *to* 200 mm., *and laterally at distances from the same line of* 25 mm., 30 mm., *and* 40 mm. *The pile was on the left side of the head, and the muscle of the right side was contracted.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	—1°	—0·0042°C.	
2 „	+5°	+0·0211°C.	
3 „	—2°	—0·0084°C.	
4 „	—5°	—0·0211°C.	
5 „	+1°	+0·0042°C.	
6½ „	+5°	+0·0211°C.	
7½ „	—8	—0·0338°C.	
8 „	—9	—0·0381°C.	
			Stopped contractions.
9, 10, 11, 12, 13, 14, 15 minutes	—8°	—0·0338°C.	Temperature oscillating.
	+1°	+0·0042°C.	
	+6°	+0·0254°C.	

In this experiment the temperature alternately fell below and rose above the starting point during the eight minutes of the contractions, the greatest fall being 0·0381° C., and the greatest rise 0·0254°C. During the seven minutes of repose succeeding the contractions, the temperature fluctuated, touching, successively, points 0·0042° C. and 0·0254° C. above, and 0·0338° C. below the initial temperature.

2nd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
8 minutes	+5°.....	+0·0208°C.	
			Stopped contractions.
9, 10, 11, 12, 13 minutes	0°.....	0°	

In this experiment at the end of eight minutes of contractions a rise of 0·0208° C. had occurred. During the five minutes of repose following, the temperature fell back to the starting point, and stood there at the close of the experiment.

3rd Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6 minutes	,, ...	,,	
7 minutes	+6°.....	+0·025°C.	
			Stopped contractions.
8, 9, 10, 11, 12 minutes	0°.....	0°	

In this experiment at the end of seven minutes' muscular action, the temperature stood at 0·025° C. above the starting point. Subsequently a fall to zero ensued, and this latter temperature was preserved during five minutes of repose.

4th Experiment.

1° deflection of galvanometer is equal to 0·004166°C.

At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	,, ...	,,	
			Stopped contractions.
8, 9, 10, 11, 12 ,,	,, ...	,,	

No change of temperature either during or after the contractions.

5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th, and 16th Experiments were made under the same conditions as 4th Experiment, and furnished the same negative results as the latter.

Our sixteen experiments may be grouped as follows:

	Number of cases. —	Percentages. —	Where found. — Experiments.
a. Cases of rise of temperature, followed by a fall to the starting point	2	12·50	2nd and 3rd.
b. „ rise and fall together, the fall being greater than the rise.....	1	6·25	1st.
c. „ temperature remaining unchanged	13	81·25	4th to 16th inclusive.

Dr. Amidon has tabulated the results of sixty-two experiments on this muscle.* From them we obtain the following values :

	Number of cases. —	Percentages. —	
Rise of temperature.....	40	64·5161	Average rise, 0·2868°C.
Fall „	4	6·4517	Maximum „ 1·25°C.
Temperature unchanged.....	18	29·0322	Minimum „ 0·0555°C.

Experiments on the contraction of the trapezius and the levator anguli scapulæ. The thermo-pile was placed at a point distant from the root of the nose, on the median line, 120 mm. *to* 130 mm., *and distant laterally from the same line* 20 mm. *to* 40 mm. *The pile was on the left side of the head, and the muscles of the right side were contracted.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions. —	Rise or fall of temperature. Deflections of galvanometer. —	Rise or fall of temperature. Thermometric values. —	Comments. —
At the end of—			
0 minutes	0°.....	0	Commenced contractions.
1 „	—2°.....	—0·0084°C.	
2 „	—11°.....	—0·0466°C.	
3 „	— „	— „	
3½ „	—5°.....	—0·0211°C.	
4 „	—4°.....	—0·0169°C.	
5 „	—6°.....	—0·0254°C.	
5½ „	—4°.....	—0·0169°C.	
6 „	+2°.....	+0·0084°C.	

* Op. cit., p. 24.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
7 minutes	0°	0°	
			Stopped contractions.
8, 9, 10, 11 minutes	−6°	−0·0254°C.	Temperature oscillating.
	+4°	+0·0169°C.	
12 minutes	−1°	−0·00423°C.	

We have here, during seven minutes of contractions (with the exception of a temporary rise of 0·0084° C. in the sixth minute), a temperature continuously at or below the starting point, the maximum fall being 0·0466° C. During four minutes of inactivity immediately following the contractions the temperature fluctuated between 0·0254° C. below, and 0·0169° C. above, the starting point. When the experiment closed—at the end of the twelfth minute from the commencement—the temperature was 0·00423° C. below the zero.

2nd Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
2 „	−10°	−0·0423°C.	
3 „	+5°	+0·0211°C.	
4 „	+1°	+0·00423°C.	
4½ „	+10°	+0·0423°C.	
5 „	+2°	+0·0084°C.	
6 „	−5°	−0·0211°C.	
7 „	−2°	−0·0084°C.	
			Stopped contractions.
8 „	+2°	+0·0084°C.	
10 „	−3°	−0·0127°C.	
13 „	−3°	−0·0127°C.	Temperature oscillating.
	+5°	+0·0211°C.	

In this experiment the temperature fell and rose unsteadily during the seven minutes of contractions, the maximum fall and the maximum rise being each 0·0423° C. At the close of the contractions the temperature stood at 0·0084° C. below the starting point. During the subsequent period of repose the temperature varied between 0·0127° C. below, and 0·0211° C. above, the starting point.

3rd Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	+5°	+0·0211°C.	
2 „	+2°	+0·0084°C.	
3½ „	+3°	+0·0127°C.	
5 „	—3°	—0·0127°C.	
6 „	—5°	—0·0211°C.	
7 „	+4°	+0·0169°C.	
7½ „	+2°	+0·0084°C.	
8 „	+3°	+0·0127°C.	
8½ „	—4°	—0·0169°C.	Temperature oscillating.
	+3°	+0·0127°C.	
9 „	—3°	—0·0127°C.	
10 „	+2°	+0·0084°C.	
			Stopped contractions.
11, 12, 13, 14 minutes	—5°	—0·0211°C.	Temperature oscillating.
	+3°	+0·0127°C.	
15 „	—5°	—0·0211°C.	

In this experiment the temperature fluctuated unsteadily, both during the contractions and during five minutes of subsequent inactivity. The maximum rise and fall during the contractions were equal, namely, 0·0211° C. During the period of repose the maximum fall was 0·0211° C., and the maximum rise was 0·0127° C. At the close of the experiment the temperature was 0·0211° C. below the starting point.

4th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—		
0 minutes	0°	0° Commenced contractions.
1, 2, 3, 4, 5, 6, 7, 8 minutes	„	„
		Stopped contractions.
9, 10, 11, 12, 13 minutes	„	„

No change of temperature either during or after the contractions.

5th, 6th, 7th, and 8th Experiments, made under similar conditions to 4th Experiment, gave similar negative results.

In the following two experiments the pile was placed on the left frontal eminence, 20 mm. from the median line:

9th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	— 7°	—0·0296°C.	
2 „	—13°	—0·0550°C.	
3 „	—30°	—0·1271°C.	
4 „	—40°	—0·1694°C.	
5 „	—52°	—0·2203°C.	
6 „	—57°	—0·2415°C.	
7 „	—61°	—0·2581°C.	
7½ „	—67°	—0·2838°C.	
			Stopped contractions.
8½ „	—68°	—0·2881°C.	
9½ „	—72°	—0·3050°C.	
10½ „	—74°	—0·3135°C.	
11½ „	—67°	—0·2838°C.	
12½ „	—68°	—0·2881°C.	

During the whole time of the contractions, in the above experiment, the temperature fell steadily and decidedly, the maximum fall being 0·2838° C., attained at the close of the contractions. During the succeeding five minutes of inactivity, the fall reached 0·3135° C. below the starting point. The last value recorded was 0·2881° C. below the zero. The explanation of this fall is probably that already given of similar depressions of temperature (1st Experiment on extensors of leg, p. 6).

10th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	„	„	
2 „	— 5°	—0·0211°C.	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
3 „	—10°	—0·0423°C.	
4 „	—13°	—0·0550°C.	
5 „	—15°	—0·0635°C.	
6 „	— „	— „	
7 „	—14°	—0·0593°C.	
8 „	—12°	—0·0508°C.	
8½ „	— 5°	—0·0211°C.	
9 „	0°	0°	
9½ „	+ 2°	+0·0084°C.	
10 „	+ 5°	+0·0211°C.	Stopped contractions.
11 „	— 5°	—0·0211°C.	
12 „	—10°	—0·0423°C.	
13 „	—13°	—0·0550°C.	
14 „	—11°	—0·0466°C.	
15 „	—12°	—0·0508°C.	

In this experiment, during the first five minutes, the temperature fell steadily, reaching at the end of this time a point, 0·0635° C., below the zero. After being stationary for a minute the temperature began to rise steadily towards zero, reaching this point at the end of the ninth minute, and passing 0·0211° C. above it in the succeeding minute. During the five minutes of repose following the contractions the temperature again fell below the starting point, being, at the end of the thirteenth minute from the commencement of the experiment, 0·055° C. below the zero. At the close of the experiment the temperature was still below the starting point by 0·0508° C.

We may group our ten experiments on the trapezius and levator anguli scapulæ as follows:

	Number of cases.	Percentages.	Where found. Experiments.
a. Cases of rise of temperature counterbalanced by equal fall below starting point	2 ...	20 ...	2nd and 3rd.
b. „ rise and fall together, the fall being greater than the rise	2 ...	20 ...	1st and 10th.
c. „ temperature remaining unchanged	5 ...	50 ...	4th, 5th, 6th, 7th and 8th.
d. „ fall to a lower general level	1 ...	10 ...	9th.

The average highest rise was 0·0253° C., the maximum and minimum being, respectively, 0·0423° C. and 0·0169° C. The average greatest fall was 0·0433° C., the maximum being 0·0635° C., and the minimum 0·0211° C.

From Dr. Amidon's table of ninety-three experiments on these muscles we deduce the following values :*

	Number of cases.	Per-centages.	
Rise of temperature.....	52	55·9140	Average rise, 0·3552°C.
Fall „	2	2·1505	Maximum „ 0·9722°C.
Temperature unchanged.....	39	41·9355	Minimum „ 0·1388°C.

Experiments on the contraction of the orbicularis palpebrarum. The thermo-pile was placed at a point situated between 90 mm. *and* 110 mm. *above the centre of the external auditory meatus, and* 30 mm. *posteriorly to the latter. The pile was on the left side of the head, and the muscle of the right side was contracted.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes.....	0°.....	0°	Commenced contractions.
1 „	+3°.....	+0·0127°C.	
2 „	+5°.....	+0·0211°C.	
3 „	—7°.....	—0·0296°C.	
4 „	—5°.....	—0·0211°C.	
5 „	+1°.....	+0·00423°C.	
5½ „	—3°.....	—0·0127°C.	
6½ „	—„	— „	
7 „	0°.....	0°	
			Stopped contractions.
8, 9, 10, 11, 12, 13, 14 minutes	−2°.....	−0·0084°C.	Temperature oscillating.
	0°.....	0°	
	+3°.....	+0·0127°C.	

* Op. cit., p. 31.

In this experiment the temperature rose during the first two minutes 0·0211° C., but during the next minute it fell 0·0296° C. below the starting point. At the end of the fifth minute the zero had again been passed, and a positive rise of 0·00423° C. noted. During the next minute and a half another fall occurred to 0·0127° C. below the zero. At the end of the last minute of the contractions the temperature was back at the starting point. Seven minutes of subsequent inactivity showed an oscillation about the zero, with a range of 0·0084° C. below, and of 0·0127° C. above, that point.

2nd Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
½ „	„	„	
1 „	+1°	+0·00423°C.	
2 „	—3°	—0·0127°C.	
3 „	+7°	+0·0296°C.	
4 „	+4°	+0·0169°C.	
5 „	—9°	—0·0381°C.	Temperature oscillating.
	—4°	—0·0169°C.	
	+2°	+0·0084°C.	
			Stopped contractions.
6, 7, 8 minutes	—9°	—0·0381°C.	Temperature oscillating.
	—4°	—0·0169°C.	
	+2°	+0·0084°C.	
9 minutes	—11°	—0·0466°C.	
10 „	+3°	+0·0127°C.	
11½ „	—1°	—0·00423°C.	
	+3°	+0·0127°C.	
	+7°	+0·0296°C.	

In this experiment, after a rise of 0·00423° C. at the end of the first minute, the temperature fell 0·0127° C. below the starting point. At the end of the third minute, however, it stood at 0·0296° C. above the zero. During the last (fifth) minute of the contractions it was, by turns, 0·0381° C. and 0·0169° C. below, and 0·0084° C. above the starting

point. These values were unchanged during the first three minutes of repose, but in the ninth minute from the commencement of the experiment the temperature fell to 0·0466° C. below the zero. During the final minute and a half of the observations, the temperature fluctuated between 0·00423° C. below, and 0·0127° C. to 0·0296° C. above the starting point.

3rd Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
½ „	+5°	+0·0211°C.	
1 „	+2°	+0·0084°C.	
2 „	—1°	—0·00423°C.	
3 „	—15°	—0·0635°C.	
4 „	—7°	—0·0296°C.	
4½ „	—5°	—0·0211°C.	
5 „	—2°	—0·0084°C.	
6 „	+2°	+0·0084°C.	
7 „	+„	+ „	
7½ „	+5°	+0·0211°C.	
8 „	+1°	+0·00423°C.	
9 „	—2°	—0·0084°C.	
9½ „	+„	+ „	
10 „	—„	— „	
			Stopped contractions.
11,12,13,14,15 minutes	—5° / +7°	—0·0211°C. / +0·0296°C.	Temperature oscillating.
16 „	—1°	—0·00423°C.	

In the above experiment we have, first—at the end of half a minute—a rise of 0·0211° C.; then, a fall, which, at the end of the third minute, carried the temperature to 0·0635° C. below the starting point; after this a gradual recovery, amounting, at the end of seven and a half minutes from the commencement of the experiment, to 0·0211° C. positive rise; and finally another fall to 0·0084° C. below the starting point, with a temporary recovery (at the end of nine and a half minutes) to 0·0084° C. above the zero intervening. During the first five minutes of repose, the temperature

fluctuated between 0·0211° C. below, and 0·0296° C. above the starting point; the last temperature noted (end of sixteenth minute) was 0·00423° C. below that point.

4th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°.....	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7 minutes	„	„	
			Stopped contractions.
8, 9, 10, 11, 12 „	„	„	

No change of temperature, either during or after the contractions.

5th, 6th, 7th, 8th, 9th, and 10th Experiments, made under conditions identical with those of 4th Experiment, furnished similar negative results.

We will group our ten experiments on the orbicularis palpebrarum as follows:

		Number of cases.	Per-centages.	Where found. — Experiments.
a.	Cases of rise and fall of temperature together, the fall being greater than the rise.....	3 ...	30 ...	1st, 2nd, 3rd.
b.	„ temperature remaining unchanged	7 ...	70 ...	4th, 5th, 6th, 7th, 8th, 9th, 10th.

The average highest rise was 0·0466° C., the extremes being 0·0635° C., and 0·0296° C. The average lowest fall was 0·0268° C., the extremes being 0·0296° C., and 0·0211° C.

From Dr. Amidon's table of thirty-six experiments on this muscle we obtain the following figures :*

	Number of cases.	Per-centages.	
Rise of temperature.....	30 ...	83·3334 ...	Average rise, 0·3425°C.
Fall „	1 ...	2·7777 ...	Maximum „ 0·8333°C.
Temperature unchanged.....	5 ...	13·8889 ...	Minimum „ 0·1388°C.

* Op. cit., p. 42.

Experiments on the contraction of the orbicularis palpebrarum, levator labii superioris proprius, zygomatici, and risorius, all acting simultaneously. The point on which the thermo-pile was placed, was situated between 90 *and* 110 mm. *above the centre of the external auditory meatus, and* 30 mm. *posteriorly to the latter. In the first three experiments, the pile was on the* RIGHT *side of the head, and the muscles of the* LEFT *side were contracted. This arrangement was necessitated by the inability of the subject to contract the muscles of the right side. In the subsequent six experiments, the pile was on the left side as usual, the subject being changed.*

1st Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
1 „	+7°	+0·0296°C.	
2 „	+6°	+0·0254°C.	
3 „	+4°	+0·0169°C.	
3½ „	+5°	+0·0211°C.	
4 „	+10°	+0·0423°C.	
5 „	+ „	+ „	
6 „	+8°	+0·0338°C.	
7 „	+3°	+0·0127°C.	
7½ „	—5°	—0·0211°C.	
8 „	—8°	—0·0338°C.	
8½ „	—12°	—0·0508°C.	
9 „	—13°	—0·0550°C.	
			Stopped contractions.
11 „	—36°	—0·1525°C.	
12½ „	—43°	—0·1821°C.	
14 „	—34°	—0·1440°C.	

In this experiment the temperature, at the end of the first minute, stood 0·0296° C. above the starting point. By the end of the third minute, this rise had been reduced to 0·0169° C.; but subsequently a fresh rise occurred, the temperature mounting to 0·0423° C. above the starting point, in the fourth minute; but, setting out from this time a

steady fall commenced, 0·0338° C. below the starting point being noted at the end of the eighth minute. During the last minute of the contractions the temperature fell to 0·055° C. below the starting point. The subsequent period of inactivity was marked by a still greater fall, the maximum depression—at the end of twelve and a half minutes from the commencement of the experiment—being 0·1821° C.; the last fall was, however, probably due to causes other than the muscular action, as in similar cases given before (1st Experiment on extensors of leg, p. 6).

2nd Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes.....	0°.....	0°	Commenced contractions.
1 „	—1°.....	—0·00423°C.	
2 „	—5°.....	—0·0211°C.	
3 „	—15°.....	—0·0635°C.	
4 „	—21°.....	—0·0889°C.	
5 „	—23°.....	—0·0975°C.	
6 „	—25°.....	—0·1059°C.	
7 „	— „	— „	
8 „	— „	— „	
			Stopped contractions.
10 „	—36°.....	—0·1525°C.	
11 „	—37°.....	—0·1567°C.	
12 „	—40°.....	—0·1694°C,	
13 „	—55°.....	—0·2330°C.	

Here we have a steady fall of temperature from the beginning to the end of the experiment, probably owing chiefly to a fall of thermal level, and not to the muscular movements.

3rd Experiments.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—			
0 minutes.....	0°.....	0°	Commenced contractions
1 „	„	„	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments
At the end of—			
2 minutes	+1°	+0·00423°C.	
3 „	+„	„	
4 „	+4°	+0·0169°C.	
4½ „	+2°	+0·0084°C.	
5 „	+„	+„	
6 „	0°	0°	
6½ „	−1°	−0·00423°C.	
7 „	+2°	+0·0084°C.	
7½ „	−2°	−0·0084°C.	
8½ „	−6°	−0·0254°C.	Stopped contractions.
9½ „	−4°	−0·0169°C.	
11½ „	−8°	−0·0338°C.	
12½ „	−6°	−0·0254°C.	
13½ „	−4°	−0·0169°C.	
14½ „	−6°	−0·0254°C.	

In the above experiment, the temperature rose during the first few minutes, reaching at the end of the fourth minute 0·0169° C. above the starting point. After this time, however, it commenced to fall, touching zero at the end of the sixth minute, and passing 0·00423° C. below this point in the half minute following. A recovery to 0·0084° C. above the zero took place in the seventh minute, but the temperature again fell, and when the contractions were stopped—at the end of eight and a half minutes—the reading was 0·0254° C. below the starting point. Three minutes after the close of the contractions, the fall had increased to 0·0338° C., and at the close of the observations—fourteen and a half minutes from the commencement of the experiment—the temperature was still below the zero by 0·0254° C.

4th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—			
0 minutes	0°	0°	Commenced contractions.
1, 2, 3, 4, 5, 6, 7, 8, 9 minutes	„	„	

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Thermometric values.	Comments.
At the end of—			
10 minutes.....	—5°	—0·0211°C.	
			Stopped contractions.
11, 12, 13, 14, 15, 16 minutes	—„	— „	

During the first nine minutes of contractions, in the above experiment, the temperature was unaffected, but at the end of the tenth minute—when the contractions were stopped—a fall of 0·0211° C. below the starting point had taken place. The temperature remained at this same degree of depression during six minutes of inactivity following the contractions.

5th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

At the end of—			
0 minutes.....	0°.....	0°	Commenced contractions.
½ „	„	„	
1 „	+4°.....	+0·0169°C.	
2 „	+1°.....	+0·00423°C.	
3 „	—1°.....	—0·00423°C.	
4 „	0°.....	0°	
5 „	—2°.....	—0·0084°C.	
6 „	+1°.....	+0·00423°C.	
7 „	—5°.....	—0·0211°C.	
			Stopped contractions.
8, 9, 10, 11 minutes...	—„	— „	
15 minutes.....	+4°.....	+0·0169°C.	
17 „	—1°.....	—0·00423°C.	

In this experiment, at the end of one minute, the temperature rose 0·0169° C. above the starting point; it declined, however, in the succeeding minutes, touching zero at the end of the fourth minute, and passing 0·0084° C. below this point in the fifth minute. The sixth minute showed a temporary recovery to 0·00423° C. above the starting point; but during the last (seventh) minute of the contractions the temperature fell to 0·0211° C. below the zero. During the subsequent ten minutes of repose, the temperature, at one

time, rose to 0·0169° C. above the starting point, but at the close of the experiment it was 0·00423° C. below that point.

6th Experiment.

1° deflection of galvanometer is equal to 0·004237°C.

Time from commencement of contractions.	Rise or fall of temperature. Deflections of galvanometer.	Rise or fall of temperature. Thermometric values.	Comments.
At the end of—			
0 minutes	0°	0°	Commenced contractions.
2 „	+3°	+0·0127°C.	
3 „	—1°	—0·00423°C.	
5 „	—2°	—0·0084°C.	
6 „	—3°	—0·0127°C.	
7 „	0°	0°	
8 „	+2°	+0·0084°C.	
9 „	—1°	—0·00423°C.	
9½ „	—2°	—0·0084°C.	
10 „	—1°	—0·00423°C.	
			Stopped contractions.
11, 12, 13, 14 minutes	—5°	—0·0211°C.	Temperature oscillating.
	+1°	+0·00423°C.	
15 minutes	—3°	—0·0127°C.	

We have here, first, a rise of temperature of 0·0127° C. at the end of the second minute; then a fall, during three minutes, to 0·0127° C. below the starting point; afterwards a recovery to 0·0084° C. above the zero; and finally a second fall, amounting to 0·0084° C. at the end of nine and a half minutes, and to 0·00423° C. at the close of the contractions. During the first four minutes of repose the temperature fluctuated between 0·0211° C. below and 0·00423° C. above the starting point. At the close of the experiment—at the end of the fifteenth minute—the temperature was still below the zero by 0·0127° C.

7th, 8th, and 9th Experiments—each consisting of seven minutes of contractions with five minutes subsequent repose—showed neither rise nor fall of temperature.

The nine experiments on the muscles under consideration may be classed as follows:

	Number of cases.	Percentages.	Where found. — Experiments.
a. Cases of fall of temperature without rise	1 ...	11·1112 ...	4th.
b. „ rise and fall together, the fall being greater than the rise	3 ...	33·3333 ...	3rd, 5th, and 6th.
c. „ temperature remaining unchanged	3 ...	33·3333 ...	7th, 8th, and 9th
d. „ fall to lower general level ...	2 ...	22·2222 ...	1st and 2nd.

The average highest rise was 0·014° C., the extremes being 0·0169° and 0·0084° C. The average lowest fall was 0·0243° the extremes being 0·0338° C. and 0·0211° C.

The tables of Dr. Amidon furnish the following values for the muscles in question.* The total number of experiments was sixty three.

	Number of cases.	Percentages.	
Rise of temperature.....	31 ...	49·2063 ...	Average rise, 0·2589°C.
Fall „	4 ...	6·3492 ...	Maximum „ 0·8333°C.
Temperature unchanged	28 ...	44·4445 ...	Minimum „ 0·1388°C.

It remains now to collect and to examine together all the results set forth in the six sets of experiments, which have engaged our attention. This is done in the following table:

* Op. cit., p. 43. The muscles of the mouth alone are taken, the values of the orbicularis palpebrarum having been given before.

	Quadriceps extensor cruris, &c. — Number of cases.	Calf muscles. — Number of cases.	Biceps of arm. — Number of cases.	Trapezius and levator anguli scapulæ. — Number of cases.	Orbicularis palpebrarum. — Number of cases.	Orbicularis palp., levator labii superioris, &c. — Number of cases.	Totals.	Percentages.
a. Rise without fall	1	0	2	0	0	0	3	3·7037
b. Fall without rise	2	1	0	0	0	1	4	4·9383
c. Rise and fall equal.....	4	1	0	2	0	0	7	8·6420
d. Rise and fall, the latter being the greater	8	0	1	2	3	3	17	20·9876
e. Rise and fall, the former being the greater	1	0	0	0	0	0	1	1·2345
f. Temperature unchanged	9	2	13	5	7	3	39	48·1482
g. Rise to higher general level...	3	0	0	0	0	0	3	3·7037
h. Fall to lower general level ...	4	0	0	1	0	2	7	8·6420
Totals.....	32	4	16	9	10	9	81	

A glance at the above table shows that the results of our experiments are most decidedly contradictory of the views held by Dr. Amidon. Of the eighty-one results only three, or less than four per cent., can be construed as affording evidence of a rise of temperature due to muscular contraction *per se ;* and in two of these cases (2nd and 3rd experiments on biceps, pp. 26 and 27) the rise was only temporary, the temperature falling back to the starting point in the succeeding minute. There would, indeed, seem to be much greater evidence that the muscular movements bring about a *fall* of temperature. Thus, if we leave out the ten cases of change of thermal level, we may group the rest of the results as follows :

	Number of cases.	Percentages.
a. Cases in which there was either an independent rise, or in which the latter condition predominated ...	4	5·6338
b. Cases in which there was either an independent fall, or in which the latter condition predominated... ...	21	29·5774
c. Cases in which the rise and fall were equal..... ...	7	9·8592
d. Cases in which no change of temperature occurred ...	39	54·9296

Here we see that the cases in which a fall of temperature is the ruling condition are more than five times as numerous as those in which a rise of temperature prevails.

But although there is not sufficient proof of a rise of temperature in the head, specially due to muscular contraction (leaving out the question of exact localization of such a rise), yet it would seem, that, in a certain number of cases, the muscular movements, *in some way, cause a disturbance of the temperature of the head,* this disturbance showing itself in elevations or depressions, or again, in irregular fluctuations, of temperature. In fact, the variations of temperature noted in a number of the experiments were greater than those ordinarily met with in the quiescent mental state; but in exactly what way these variations are connected with the muscular movements is not yet clear.

Note to Experiments on the Effect of Voluntary Muscular Contractions.

While these investigations were in the press the writer learned, for the first time, that both M. Paul Bert and M. François Franck had, in the past spring and summer (1880), repeated Dr. Amidon's experiments, and had failed to confirm his results. The writer has not seen the published accounts of MM. Bert and Franck, and knows their investigations only through an indirect and general report.

EXPERIMENTS

ON THE

INFLUENCE OF THE TEMPERATURE OF THE AIR

ON THE

TEMPERATURE OF THE HEAD.

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EXPERIMENTS

ON THE

INFLUENCE OF THE TEMPERATURE OF THE AIR

ON THE

TEMPERATURE OF THE HEAD.

The object of the experiments contained in the following tables was to obtain a general idea of the extent to which the temperature of the surface of the head is affected by the temperature of the surrounding air. The observations were made on two individuals, both the subjects of many previous experiments of a similar nature, and in whom the ordinary normal variations of the temperature of the head had been proved to be nearly the same. In the different observations all the essential experimental conditions, except the temperature of the air, were, as far as possible, regulated to uniformity. Both thermometers and thermo-electric apparatus were employed in obtaining the temperature of the head, which was taken on the left side in the space behind the external angular process described in the first article of this book.* The method of procedure was to note the temperatures of the air, and of the head, respectively, in five successive observations at intervals of one minute each, after waiting, in the first instance, a sufficient time for equilibrium to be established between the instrument—thermometer, or thermo-pile—and the head. If, at the end of the five

* P. 8.

minutes, no alteration of temperature either of the air or of the head had occurred, the temperature of the air was changed artificially, and a new set of observations made. The results contained in the tables are, therefore, in sets of five observations each, or in some multiple of that number, when two or more similar sets are added together in one item.

Each of the first four tables represents a separate and distinct period of investigation extending over two or three months.

TABLE 1.

Temperatures of		Number of experiments.	Temperatures of		Number of experiments.
Air.	Head.		Air.	Head.	
21·1111°C.	36·30°C.	5	18·3333°C.	35·75°C.	5
,,	35·90°C.	,,	,,	35·50°C.	10
,,	35·80°C.	,,	18·0555°C.	35·90°C.	5
20·8333°C.	36·40°C.	,,	,,	35·85°C.	,,
,,	36·15°C.	,,	,,	35·80°C.	,,
,,	36·00°C.	,,	,,	35·55°C.	,,
20·7500°C.	36·00°C.	,,	,,	35·50°C.	,,
,,	35·80°C.	10	,,	35·45°C.	,,
,,	35·30°C.	5	17·5000°C.	36·00°C.	10
20·0000°C.	36·20°C.	,,	,,	35·65°C.	5
,,	36·15°C.	,,	,,	35·30°C.	,,
,,	36·10°C.	,,	,,	35·00°C.	,,
,,	36·00°C.	,,	17·2222°C.	36·00°C.	10
,,	35·95°C.	,,	,,	35·60°C.	5
,,	35·90°C.	,,	,,	35·50°C.	10
,,	35·80°C.	20	16·6666°C.	35·80°C.	5
19·4444°C.	35·95°C.	5	,,	35·60°C.	,,
,,	35·80°C.	,,	,,	35·50°C.	,,
18·3333°C.	35·80°C.	10			

TABLE 2.

17·2222°C.	35·40°C.	10	15·0000°C.	35·15°C.	5
16·6666°C.	35·35°C.	5	14·5000°C.	35·20°C.	10
,,	34·90°C.	10	,,	35·15°C.	5
,,	34·85°C.	5	14·4444°C.	35·35°C.	10
16·1111°C.	35·50°C.	,,	,,	35·30°C.	,,
,,	35·40°C.	15	13·8888°C.	35·90°C.	5
,,	35·00°C.	5	,,	35·40°C.	10
,,	34·80°C.	,,	,,	35·35°C.	,,
15·5555°C.	35·50°C.	,,	,,	35·30°C.	,,
,,	35·20°C.	10	,,	35·25°C.	5
15·0000°C.	35·40°C.	,,	,,	35·20°C.	10

Temperatures of		Number of experiments.	Temperatures of		Number of experiments.
Air.	Head.		Air.	Head.	
13·8888°C.	35·00°C.	20	11·7222°C.	34·70°C.	5
,,	34·90°C.	5	,,	34·20°C.	,,
13·3333°C.	35·35°C.	,,	11·6666°C.	35·65°C.	,,
,,	35·20°C.	10	,,	35·40°C.	,,
,,	34·90°C.	,,	,,	35·20°C.	10
,,	34·60°C.	5	,,	34·25°C.	5
,,	34·40°C.	,,	11·1111°C.	35·35°C.	,,
12·7777°C.	35·70°C.	10	,,	34·35°C.	,,
12·2255°C.	34·50°C.	5	,,	34·25°C.	,,
12·2222°C.	35·05°C.	,,	,,	33·90°C.	,,
,,	34·50°C.	,,	,,	33·80°C.	,,
11·7222°C.	35·10°C.	,,	10·5555°C.	34·30°C.	,,
,,	35·00°C.	,,			

Table 3.

14·1666°C.	35·55°C.	5	8·8888°C.	35·20°C.	10
13·3333°C.	35·90°C.	,,	,,	35·10°C.	,,
,,	35·75°C.	,,	,,	35·05°C.	5
,,	35·60°C.	,,	,,	34·90°C.	,,
,,	35·15°C.	,,	,,	34·80°C.	15
12·7777°C.	35·00°C.	,,	,,	34·75°C.	5
12·4444°C.	35·50°C.	,,	,,	34·60°C.	10
12·2222°C.	35·90°C.	,,	,,	34·55°C.	5
,,	35·70°C.	,,	,,	34·30°C.	,,
11·9444°C.	35·80°C.	,,	,,	34·25°C.	,,
11·6666°C.	35·60°C.	10	,,	34·20°C.	10
11·1111°C.	35·75°C.	5	,,	34·15°C.	5
,,	35·45°C.	,,	,,	33·95°C.	,,
,,	35·40°C.	,,	,,	33·65°C.	,,
10·0000°C.	35·40°C.	,,	,,	33·10°C.	,,
,,	35·20°C.	,,	8·3333°C.	34·90°C.	,,
,,	35·00°C.	,,	,,	34·60°C.	,,
,,	34·65°C.	,,	,,	34·30°C.	10
,,	34·20°C.	,,	,,	34·10°C.	5
9·4444°C.	35·50°C.	,,	,,	33·45°C.	10
,,	35·25°C.	,,	7·7777°C.	34·55°C.	,,
,,	35·20°C.	,,	,,	34·40°C.	5
,,	35·10°C	,,	,,	34·20°C.	10
,,	34·40°C.	,,	,,	34·05°C.	,,
8·8888°C.	35·50°C.	,,			

TABLE 4.

Temperatures of Air.	Temperatures of Head.	Number of experiments.	Temperatures of Air.	Temperatures of Head.	Number of experiments.
14·1666°C.	35·55°C.	10	6·1111°C.	33·90°C.	10
13·3333°C.	35·90°C.	5	,,	33·30°C.	5
,,	35·75°C.	,,	5·5555°C.	34·30°C.	10
,,	35·60°C.	,,	,,	33·90°C.	5
,,	35·15°C.	,,	,,	33·80°C.	,,
12·4444°C.	36·10°C.	,,	,,	33·70°C.	,,
,,	35·80°C.	,,	5·0000°C.	34·00°C.	,,
12·2222°C.	35·90°C.	10	,,	33·90°C.	10
11·1111°C.	35·75°C.	,,	,,	32·80°C.	5
,,	35·45°C.	5	,,	32·55°C.	,,
,,	35·40°C.	,,	4·5000°C.	34·20°C.	,,
10·0000°C.	35·40°C.	,,	,,	34·10°C.	,,
,,	35·20°C.	,,	,,	33·95°C.	10
,,	35·00°C.	,,	,,	33·85°C.	5
,,	34·65°C.	10	,,	33·75°C.	,,
9·4444°C.	35·50°C.	,,	,,	32·60°C.	,,
,,	34·70°C.	,,	4·0000°C.	34·30°C.	,,
,,	34·40°C.	,,	,,	34·00°C.	,,
,,	34·30°C.	15	,,	33·95°C.	,,
8·8888°C.	35·80°C.	10	,,	32·55°C.	,,
,,	35·20°C.	,,	3·5555°C.	33·95°C.	10
,,	35·05°C.	5	,,	33·80°C.	5
,,	34·90°C.	10	,,	33·55°C.	,,
,,	33·95°C.	5	,,	32·55°C.	,,
,,	33·53°C.	,,	,,	32·50°C.	,,
,,	33·10°C.	,,	2·5555°C.	34·00°C.	,,
8·3333°C.	34·90°C.	,,	,,	33·85°C.	10
,,	34·60°C.	15	,,	33·70°C.	5
,,	34·30°C.	5	,,	33·50°C.	,,
,,	34·10°C.	,,	,,	32·90°C.	,,
7·7777°C.	34·55°C.	10	,,	32·50°C.	,,
,,	34·40°C.	,,	2·0000°C.	33·95°C.	,,
,,	34·20°C.	,,	,,	33·80°C.	10
,,	34·05°C.	,,	,,	32·50°C.	5
6·1111°C.	34·40°C.	10	,,	32·45°C.	,,
,,	34·00°C.	5			

Analysis of Tables 1, 2, 3, and 4.

a.

	Highest temperatures of air.	Accompanying temperatures of head.	Lowest temperatures of air.	Accompanying temperatures of head.	Ranges of temperatures of air.
Table 1	21·1111°C.	Maximum—36·30°C. Average—36·00°C. Minimum—35·80°C.	16·6666°C.	Maximum—35·8000°C. Average—35·6333°C. Minimum—35·5000°C.	4·4445°C.
„ 2	17·2222°C.	35·40°C.	10·5555°C.	34·3000°C.	6·6667°C.
„ 3	14·1666°C.	35·55°C.	7·7777°C.	Maximum—34·5500°C. Average—34·2857°C. Minimum—34·0500°C.	6·3889°C.
„ 4	14·1666°C.	35·55°C.	2·0000°C.	Maximum—33·9500°C. Average—33·3000°C. Minimum—32·4500°C.	12·1666°C.

b.

	Highest temperatures of head.	Accompanying temperatures of air.	Lowest temperatures. of head.	Accompanying temperatures. of air.	Ranges of temperatures of head.
Table 1	36·40°C.	20·8333°C.	35·00°C.	17·5000°C.	1·40°C.
„ 2	35·90°C.	13·8888°C.	33·80°C.	11·1111°C.	2·10°C.
„ 3	35·90°C.	Maximum—13·3333°C. Average—12·7777°C. Minimum—12·2222°C.	33·10°C.	8·8888°C.	2·80°C.
„ 4	36·10°C.	12·4444°C.	32·45°C.	2·0000°C.	3·65°C.

Commencing with the division "a" of the analysis, we find that, in each table, the highest temperature of the air is associated with a higher temperature of the head—average, maximum, and minimum temperatures all included—than the lowest temperature of the air. Thus in Table 1, the temperature of the head for the highest temperature of the air is, on an average, 0·3667° C. above the corresponding value, associated with the lowest temperature of the air. The degrees of superiority of the temperature of the head at the higher of the two temperatures of the air, in each table, are as follows :

Degrees of superiority of temperature of the head at the higher of the two temperatures of the air given in the analysis.	Table 1.	Table 2.	Table 3.	Table 4.
Maximum—	0·5000°C...	1·1000°C...	1·0000°C...	1·6000°C.
Average—	0·3667°C...	„	...1·2643°C...	2·2500°C.
Minimum—	0·3000°C...	„	...1·5000°C...	3·1000°C.

Moreover, if the tables are compared with each other, there appears, at first sight, to be a certain rough relation between the degree of difference of the two atmospheric temperatures and the degree of difference of the corresponding two temperatures of the head; thus in Table 1, for a difference of 4·4445° C. in the air, we have an average difference in the head of 0·3667° C.; while in Table 2, for a difference in the air of 6.6667° C., there is an average difference in the head of 1·1° C.; and in Table 4, the difference in the air being now 12·1666° C., we have a difference in the head of 2·25° C.

In proof, however, that the above relation is by no means a close one, if we take the difference between the two temperatures of the air, and the difference between the two average temperatures of the head, in Table 1, each as equal to 1, we have the following proportional values for the corresponding differences in the other tables.

	Table 1.	Table 2.	Table 3.	Table 4.
Proportional differences in temperatures of air.....	1·000°C.....	1·50°C.	1·437°C.....	2·737°C.
Proportional differences in temperatures of head	1·000°C.....	3·000°C.....	3·447°C.....	6·108°C.

Thus in Table 2, for a difference between the two atmospheric temperatures 1·5 times greater than the similar difference in Table 1, we have a difference between the two average temperatures of the head three times greater than the corresponding difference in Table 1; while in Table 4, for an atmospheric difference 2·737 times greater than that of Table 1, we find a difference of average temperature in the head 6·108 times greater than the corresponding difference in Table 1. The rate of change of average temperature in the head for each degree Centigrade of difference of temperature in the air, between the highest and lowest thermal levels of the latter, in each table, is as follows :

Rate of change in average temperature of head for each degree Centigrade of change in temperature of air	Table 1.	Table 2.	Table 3.	Table 4.
	0·0825°C.	0·165°C.	0·1978°C.	0·185°C.

Comparing, still further, with each other, the results of the analysis of the different tables in division "a," we see that although the highest and lowest temperatures of the head there given (average, maximum, and minimum all included) are associated respectively with the highest and lowest atmospheric temperatures, yet beyond this accordance discrepancies exist. Thus Table 2 with a temperature of the air of 17·2222° C. shows a temperature of the head of 35·40° C.; while in Table 1, with a temperature of the air of 16·6666° C, we have an average temperature of the head of 35·6333° C., with a maximum of 35·8° C., and a minimum of 35·5° C. Again, Tables 3 and 4, with a temperature of the air of 14·1666° C. give a temperature of the head of 35·55° C., Table 2—as we have just seen—giving a temperature of the head of 35·40 for an atmospheric temperature of 17·2222° C. The question with which we are dealing is still further elucidated by the results of division "b" of the analysis. We find here that the lowest individual temperature of the head is associated with the lowest individual temperature of the air, but that the highest individual temperature of the head occurs not with the *highest*, but with the *second highest* individual temperature of the air, namely,

20·8333° C. In like manner, in Tables 2 and 3, in which the highest temperature of the head noted is 35·90° C., this value coexists, in the first instance, with a temperature of the air of 13·8888° C., and in the second instance with a temperature of the air averaging 12·7777° C.—the maximum and minimum being, respectively, 13·3333° C., and 12·2222° C.—while the highest temperatures of the air noted in these two tables are, as we have seen, 17·2222° C., and 14·1666° C., respectively. Also Table 4, in which the highest temperature of the air is 14·1666° C., shows the highest temperature of the head coexisting with a temperature of the air of 12·4444° C. In Table 1, the lowest temperature of the head is found with an atmospheric temperature of 17·5° C., the lowest temperature of the air being 16·6666° C. Again, in Tables 2 and 3, the lowest temperatures of the head are associated with temperatures of the air of 11·1111° C., and 8·8888° C., respectively, while the lowest temperatures of the air in these tables are, respectively, 10·5555° C., and 7·7777° C.

Table 5 gives the average, maximum, and minimum temperatures of the head, associated with each of the thirty-nine temperatures of the air, at which observations have been made—all four of the preceding tables being included in the estimates. The fifth column of the table gives the proportional values of the averages of the temperatures of the head, taking the lowest average, 33·3° C. as equal to 1000.

Tables 5.

Temperatures of air.	Temperatures of head.			Proportional values of average temperatures of head.
	Average.	Maximum.	Minimum.	
21·1111°C.	36·0000°C.	36·3000°C.	35·8000°C.	1081·0
20·8333°C.	36·1833°C.	36·4000°C.	36·0000°C.	1086·6
20·7500°C.	35·7250°C.	36·0000°C.	35·3000°C.	1072·8
20·0000°C.	35·9500°C.	36·2000°C.	35·8000°C.	1079·6
19·4444°C.	35·8750°C.	35·9500°C.	35·8000°C.	1077·3
18·3333°C.	35·6700°C.	35·8000°C.	35·5000°C.	1071·1
18·0555°C.	35·6750°C.	35·9000°C.	35·4500°C.	1071·3
17·5000°C.	35·5900°C.	36·0000°C.	35·0000°C.	1068·7
17·2222°C.	35·6286°C.	36·0000°C.	35·4000°C.	1069·9
16·6666°C.	35·2714°C.	35·8000°C.	34·8500°C.	1059·2
16·1111°C.	35·2500°C.	35·5000°C.	34·8000°C.	1058·5
15·5555°C.	35·3000°C.	35·5000°C.	35·2000°C.	1060·0
15·0000°C.	35·3166°C.	35·4000°C.	35·1500°C.	1060·5
14·5000°C.	35·1833°C.	35·2000°C.	35·1500°C.	1056·6
14·4444°C.	35·3250°C.	35·3500°C.	35·3000°C.	1060·8
14·1666°C.	35·5500°C.	35·5500°C.	35·5500°C.	1067·6
13·8888°C.	35·2333°C.	35·9000°C.	34·9000°C.	1058·0
13·3333°C.	35·3393°C.	35·9000°C.	34·4000°C.	1061·2
12·7777°C.	35·4666°C.	35·7000°C.	35·0000°C.	1065·0
12·4444°C.	35·7666°C.	36·1000°C.	35·4000°C.	1073·8
12·2222°C.	35·3644°C.	35·9000°C.	34·5000°C.	1061·9
11·9444°C.	35·8000°C.	35·8000°C.	35·8000°C.	1075·0
11·7222°C.	34·7500°C.	35·1000°C.	34·2000°C.	1043·5
11·6666°C.	35·2714°C.	35·6500°C.	34·2500°C.	1059·2
11·1111°C.	35·1136°C.	35·7500°C.	33·8000°C.	1054·4
10·5555°C.	34·3000°C.	34·3000°C.	34·3000°C.	1030·0
10·0000°C.	34·9350°C.	34·4000°C.	34·2000°C.	1049·0
9·4444°C.	34·8136°C.	35·5000°C.	34·3000°C.	1045·4
8·8888°C.	34·6304°C.	35·8000°C.	33·1000°C.	1039·9
8·3333°C.	34·3230°C.	34·9000°C.	33·4500°C.	1030·7
7·7777°C.	34·2933°C.	34·5500°C.	34·0500°C.	1029·8
6·1111°C.	33·9833°C.	34·4000°C.	33·3000°C.	1020·5
5·5555°C.	34·0000°C.	34·3000°C.	33·7000°C.	1021·0
5·0000°C.	33·4300°C.	34·0000°C.	32·5500°C.	1004·0
4·5000°C.	33·7714°C.	34·2000°C.	32·6000°C.	1014·3
4·0000°C.	33·7000°C.	34·3000°C.	32·5500°C.	1012·0
3·5555°C.	33·3833°C.	33·9500°C.	32·5000°C.	1002·5
2·5555°C.	33·4714°C.	34·0000°C.	32·5000°C.	1005·1
2·0000°C.	33·3000°C.	33·9500°C.	32·4500°C.	1000·0

It will be seen from these proportional values, that although there is a general tendency in the head towards a higher average temperature as we go up the scale of atmospheric temperature, yet there are many and marked breaks and retrogressions in this upward movement. For example, at a temperature of the air of 11·9444° C., the average temperature of the head is found to be 35·8° C.; but this temperature is reduced in the next higher observation in the scale of atmospheric temperatures—then partly regained, but again reduced—and finally, after fluctuating up and down—without, however, rising so high as 35·8° C.—passes above its first point only at a temperature of the air of 19·4444° C. Again, the temperature of the head—average, maximum, and minimum all included—is higher with the temperature of the air at 12·4444° C. than with this latter temperature at 20·75° C.

Table 6, which includes all the observations of the first four tables—and in which the different individual temperatures of the head are arranged in a regular sequence from the highest to the lowest, each accompanied by the particular temperature or temperatures of the air with which it is found—shows plainly the many exceptions to an exact relation between the degree of temperature of the head and that of the air. Thus a temperature of the head of 35·5° C. is found with temperatures of the air varying from 8·8888° C. to 18·8888° C.; and a temperature of the head of 35·30° C. is found with an atmospheric temperature ranging from 13·8888° C. to 20·75° C.

If we take the average of all the temperatures of the air found with temperatures of the head at and above 35° C., and the average of all the temperatures of the air found with temperatures of the head below 35° C., we obtain the following values:

Table 6.

Temperatures of Head.	Temperatures of Air.	Number of experiments.	Tables.
36·40°C.	20·8333°C.	5	1
36·30°C.	21·1111°C.	„	„
36·20°C.	20·0000°C.	„	„
36·15°C.	20·8333°C.	„	„
„	20·0000°C.	„	„
36·10°C.	„	„	„
„	12·4444°C.	„	4
36·00°C.	20·8333°C.	„	1
„	20·7500°C.	„	„
„	20·0000°C.	„	„
„	17·5000°C.	10	„
„	17·2222°C.	„	„
35·95°C.	20·0000°C.	5	„
„	19·4444°C.	„	„
35·90°C.	21·1111°C.	„	„
„	20·0000°C.	„	„
„	18·0555°C.	„	„
„	13·8888°C.	„	2
„	13·3333°C.	„	3
„	„	„	4
„	12·2222°C.	„	3
„	„	10	4
35·85°C.	18·0555°C.	5	1
35·80°C.	21·1111°C.	„	„
„	20·7500°C.	10	„
„	20·0000°C.	20	„
„	19·4444°C.	5	„
„	18·3333°C.	10	„
„	18·0555°C.	5	„
„	16·6666°C.	„	„
„	12·4444°C.	„	4
„	11·9444°C.	„	3
„	8·8888°C.	10	4
35·75°C.	18·3333°C.	5	1
„	13·3333°C.	„	3
„	„	„	4
„	11·1111°C.	„	3
„	„	10	4
35·70°C.	12·7777°C.	„	2
„	12·2222°C.	5	3
35·65°C.	17·5000°C.	„	1
„	11·6666°C.	„	2
35·60°C.	17·2222°C.	„	1
„	16·6666°C.	„	„
„	13·3333°C.	„	3
„	„	„	4
„	11·6666°C.	10	3
35·55°C.	18·0555°C.	5	1
35·55°C.	14·1666°C.	5	3
„	„	10	4
35·50°C.	18·3333°C.	„	1
„	18·0555°C.	5	„
„	17·2222°C.	10	„
„	16·6666°C.	5	„
„	16·1111°C.	„	2
„	15·5555°C.	„	„
„	12·4444°C.	„	3
„	9·4444°C	„	„
„	„	„	4
„	8·8888°C.	„	3
35·45°C.	18·0555°C.	„	1
„	11·1111°C.	„	3
„	„	„	4
35·40°C.	17·2222°C.	10	2
„	16·1111°C.	15	„
„	15·0000°C.	10	„
„	13·8888°C.	„	„
„	11·6666°C.	5	„
„	11·1111°C.	„	3
„	„	„	4
„	10·0000°C.	„	3
„	„	„	4
35·35°C.	16·6666°C.	5	2
„	14·4444°C.	10	„
„	13·8888°C.	„	„
„	13·3333°C.	5	„
„	11·1111°C.	„	„
35·30°C.	20·7500°C.	„	1
„	17·5000°C.	„	„
„	14·4444°C.	10	2
„	13·8888°C.	„	„
35·25°C.	„	5	„
„	9·4444°C.	„	3
35·20°C.	15.5555°C.	10	2
„	14·5000°C.	„	„
„	13·8888°C.	„	„
„	13·3333°C.	„	„
„	11·6666°C.	„	„
„	10·0000°C.	5	3
„	„	„	4
„	9·4444°C.	„	3
„	8·8888°C.	10	„
„	„	„	4
35·15°C.	15·0000°C.	5	2
„	14·5000°C.	„	„
„	13·3333°C.	„	3

Temperatures of		Number of experiments.	Tables.	Temperatures of		Number of experiments.	Tables.
Head.	Air.			Head.	Air.		
35·15°C.	13·3333°C.	5	4	34·25°C.	8·8888°C.	5	3
35·10°C.	11·7222°C.	,,	2	34 20°C.	11·7222°C.	,,	2
,,	9·4444°C.	,,	3	,,	10·0000°C.	,,	3
,,	8·8888°C.	10	,,	,,	8·8888°C.	10	,,
35·05°C.	12·2222°C.	5	2	,,	7·7777°C.	,,	,,
,,	8·8888°C.	,,	3	,,	,,	,,	4
,,	,,	,,	4	,,	4·5000°C.	5	,,
35·00°C.	17·5000°C.	,,	1	34·15°C.	8·8888°C.	,,	3
,,	16·1111°C.	,,	2	34·10°C.	8·3333°C.	,,	,,
,,	13·8888°C.	20	,,	,,	,,	,,	4
,,	12·7777°C.	5	3	,,	4·5000°C.	,,	,,
,,	11·7222°C.	,,	2	34·05°C.	7·7777°C.	10	3
,,	10·0000°C.	,,	3	,,	,,	,,	4
,,	,,	,,	4	34·00°C.	6·1111°C.	5	,,
34·90°C.	16·6666°C.	10	2	,,	5·0000°C.	,,	,,
,,	13·8888°C.	5	,,	,,	4·0000°C	,,	,,
,,	13·3333°C.	10	,,	,,	2·5555°C.	,,	,,
,,	8·8888·C.	,,	3	33·95°C.	8·8888°C.	,,	3
,,	,,	5	4	,,	,,	,,	4
,,	8·3333°C.	,,	3	,,	4·5000°C.	10	,,
,,	,,	,,	4	,,	4·0000°C.	5	,,
34·85°C.	16·6666°C.	,,	2	,,	3·5555°C.	10	,,
34·80°C.	16·1111°C.	,,	,,	,,	2·0000°C.	5	,,
,,	8·8888°C.	15	3	33·90°C.	11·1111°C.	,,	2
34·75°C.	,,	5	,,	,,	6·1111°C.	10	4
34·70°C.	11·7222°C.	,,	2	,,	5·5555°C.	5	,,
,,	9·4444°C.	,,	4	,,	5·0000°C.	10	,,
34·65°C.	10·0000°C.	,,	3	33·85°C.	4·5000°C.	5	,,
,,	,,	10	4	,,	2·5555°C.	10	,,
34·60°C.	13·3333°C.	5	2	33·80°C.	11·1111°C.	5	2
,,	8·8888°C.	10	3	,,	5·5555°C.	,,	4
,,	8·3333°C.	5	4	,,	3·5555°C.	,,	,,
,,	,,	15	,,	,,	2·0000°C.	10	,,
34·55°C.	8·8888°C.	5	3	33·75°C.	4·5000°C.	5	,,
,,	7·7777°C.	10	,,	33·70°C.	5·5555°C.	,,	,,
,,	,,	,,	4	,,	2·5555°C.	,,	,,
34·50°C.	12·2255°C.	5	2	33·65°C.	8·8888°C.	,,	3
,,	12·2222°C.	,,	,,	33·55°C.	3·5555°C.	,,	4
34·40°C.	13·3333°C.	,,	,,	33·53°C.	8·8888°C.	,,	,,
,,	9·4444°C.	,,	3	33·50°C.	2·5555°C.	,,	,,
,,	,,	,,	4	33·45°C.	8·3333°C.	10	3
,,	7·7777°C.	,,	3	33·30°C.	6·1111°C.	5	4
,,	,,	10	4	33·10°C.	8·8888°C.	,,	3
,,	6·1111°C.	,,	,,	,,	,,	,,	4
34·35°C.	11·1111°C.	5	2	32·90°C.	2·5555°C.	,,	,,
34·30°C.	10·5555°C.	,,	,,	32·80°C.	5·0000°C.	,,	,,
,,	9·4444°C.	15	4	32·60°C.	4·5000°C.	,,	,,
,,	8·8888°C.	5	3	32·55°C.	5·0000°C.	,,	,,
,,	8·3333°C.	10	,,	,,	4·0000°C.	,,	,,
,,	,,	5	4	,,	3·5555°C.	,,	,,
,,	5·5555°C.	10	,,	32·50°C.	,,	,,	,,
,,	4·0000°C.	5	,,	,,	2·5555°C.	,,	,,
34·25°C.	11·6666°C.	,,	2	,,	2·0000°C.	,,	,,
,,	11·1111°C.	,,	,,	32·45°C.	,,	,,	,,

Average temperature of the air found with temperatures of the head at and above 35°C.	Average temperature of the air found with temperatures of the head below 35°C.
11·4704°C.	7·5390°C.

Here the average temperature of the air accompanying the set of higher temperatures of the head is above the corresponding value found with the set of lower temperatures of the head by 3·9310° C.

If we take the average of all the temperatures of the head found with temperatures of the air at and above 11·6666° C., and the average of all the temperatures of the head found with temperature of the air below 11·6666° C., we have the following results :

Average temperature of the head found with temperatures of the air at and above 11·6666°C.	Average temperature of the head found with temperatures of the air below 11·6666°C.
35·4647°C.	34·3117°C.

The average temperature of the head is, therefore, a little higher between 11·6666° C. and 21·1111° C. (highest temperature noted) than between 11·6666° C. and 2° C. (lowest temperature noted).

If we take the average temperature of the air, and the average temperature of the head in each table we have the following values :

	Average temperatures of air.	Average temperatures of head.
Table 1	18·9420°C.	35·7945°C.
„ 2	13·6708°C.	35·0776°C.
„ 3	9·6938°C.	34·8098°C.
„ 4	7·0147°C.	34·1939°C.

From the above values there appears to be a general relation between the average temperatures of the air and of the head in the several tables compared with each other : thus as the average temperature of the air falls, in the list, the average temperature of the head likewise declines ; but the fall in the head is but slight compared with that occurring in the air, the maximum of the former being only 1·6° C., while the latter, at its greatest, is 11·9° C.

Undoubtedly the *seasons* at which the different experiments were made have an effect on our results apart from the simple absolute temperatures concerned. There is no doubt that the vaso-motor system of nerves plays an important part in the alterations of the peripheric temperature generally; and it would further appear that the steady elevation or depression of the atmospheric thermal mean accompanying the change of the seasons, acts more constantly and persistently on these nerves than transient and irregular variations of the temperature of the air. In a recent article on the peripheric temperature, M. Louis Couty has given evidence that the temperature of the palm of the hand is affected in a manner according with the above view.* Now the experiments of Table 1 were made in August and September; those of table 2 in March and April; and those of Table 3 and 4 in December, January, and February. Unfortunately the tables for the winter months do not range sufficiently high, and those for the spring and summer months do not range sufficiently low, to admit of a comparison of the effect of the same temperature of the air, at different seasons, on the temperature of the head. To make this comparison, the ranges of the atmospheric temperatures in the tables would have to be extended both upwards and downwards by artificial means.

* "Recherches sur la température périphérique, &c.," 'Archives de Physiologie normale et pathologique,' Jan. and Feb., 1880, p. 94.

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