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THE CONSTANT ERROR OF TOUCH LOCALIZATION

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In the consideration of the ability of localization on the skin of points stimulated by light touches, by pressures, by pain stimuli, and by temperature stimuli, the conclusions of Ponzo¹ have been widely quoted and accepted.² The conclusions set forth by Ponzo in his various articles are, as I have shown in a previous publication,³ open to question in certain particulars, and it is with regard to his conclusions respecting the constant error that the present paper is presented. It is convenient to deal with these matters under the two headings of method and facts.

Method.—The usual method of determining the constant error in experiments of this character is familiar to all who have investigated these matters. It does not need to detain us long at this time. Briefly the constant error is found in the following manner: The tendency to the localization of points in a special direction is determined by referring the localizations to predetermined axes of ordinates which meet at the point of reference or origin of coördinates, which in touch localization tests is the point stimulated. The points localized to the right and those to the left of the vertical axis are considered algebraic opposites, and similarly those

¹ M. Ponzo, 'Recherches sur la localisation des sensations tactiles et des sensations douloureuses,' *Arch. ital. de biol.*, 1911, 55, 1-14.

² See, for example, the reviews of H. D. Cook in *Psychol. Bull.*, 1913, 10, 258-261; 1914, 11, 238-241.

³ S. I. Franz, 'The Accuracy of Localization of Touch Stimuli on Different Bodily Segments,' *Psychol. Rev.*, 1913, 20, 107-128.

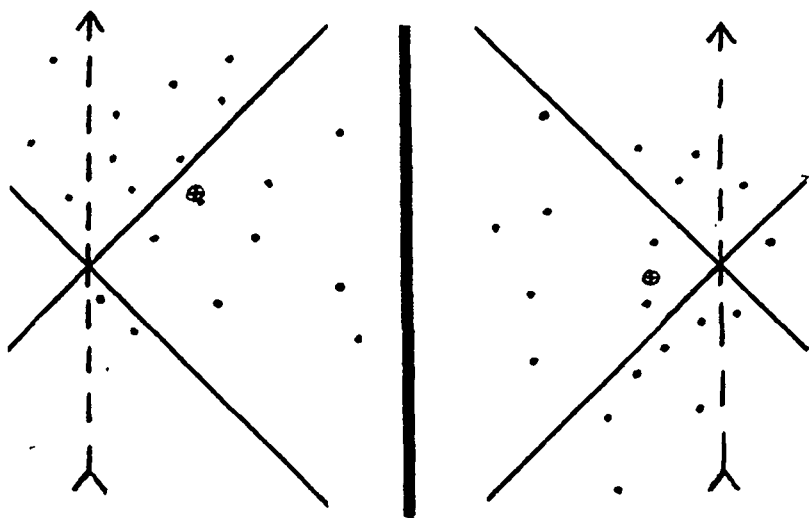
above and those below the horizontal axis. The averages of the algebraic sums will give the location of the average tendency, or the average constant error.¹

Ponzo's method of determining the constant error is, superficially, one of great simplicity, and of apparent value. Briefly in relation to the localization of the skin sensations it is as follows: Either before or after the performance of a series of tests a primary axis is drawn through the point of stimulation to represent the supposed direction of the nerve or other anatomical segmental axis; through the point two perpendicular lines are drawn in such a fashion that each cuts the primary axis at an angle of 45 degrees; the right angles which include the primary axis are then considered by Ponzo to be boundaries to those points which are in the direction of the primary axis and, consequently, to be in the direction of the anatomical part. All localizations falling within these boundaries are considered to be "in the direction of the primary axis."

A brief consideration will show that by the use of Ponzo's method conclusions may be reached which are neither accurate nor representative of the actual conditions. The extreme case of the points of localization falling close to one of the boundaries or axes of reference might show the constant error falling within the direction of the primary axis, and with a slight shifting of the points the constant error may be found to be in a direction at right angles to the primary axis. Ponzo's method breaks down in these extreme cases, and in cases which are not extremes. If the latter can be shown, we should conclude that the method is not sufficiently exact, and that conclusions based upon the method should not be accepted until they have been confirmed by facts obtained by further and more exact methods. Two illustrations will suffice to indicate the discrepancies in the conclusions to be drawn from certain results when the two methods of determining the constant error are used. The results which give these illustrations are shown in Figs. 1 and 2.

¹ These matters are so elementary that at first sight it seems superfluous to mention them, but the acceptance of Ponzo's conclusions, without due criticism, would indicate the necessity for repetition.

They show the localizations of a subject when two points on the mid-body lines were stimulated.



FIGS. 1 AND 2. Results of experiments on the localization of tactile stimuli. The points stimulated are at the intersections of the lines. The dotted lines show the principal axes, full lines, the general directions according to Ponzo. Each localization is shown as a point, the location of the average constant error as an encircled cross. Twenty tests in each experiment. For further details see texts.

In these diagrams the primary axis is shown by a broken line (with arrow markings), and Ponzo's constant error indicators are shown as unbroken lines. Each point of localization is shown as a dot, there being twenty in each illustration. Both experiments show according to Ponzo's method a superiority of localization in the direction of the primary axis. In Fig. 1 the number of points in the space 315° to 45° is 10, and in the corresponding space, 135° to 225° , 2; the numbers in the perpendicular spaces, 45° to 135° and 225° to 315° being 8 and 0 respectively. In Fig. 2 the points in the principal directions, 315° to 45° and 135° to 225° , are 5 and 7 respectively, while in the perpendicular spaces, 45° to 135° and 225° to 315° , there are 1 and 7 respectively. In each of these experiments, therefore, there are 12 points in the direction of the principal axis and 8 points not in that direction. It will thus be seen that there is an apparent

constant error (by Ponzo's method) in the direction of the principal axis, the number of such localizations being fifty per cent. more than in the other direction.

When the results in these two experiments are calculated by the usual method of determining the constant error the supposed tendency to locate along the principal axis is not found to be present. Thus, the results in Fig. 1 show an average constant error toward the right of 15.2 mm. and an upward tendency of 10.6 mm. The results in Fig. 2 show an average constant error of 11.2 mm. to the left and 1.9 mm. downward. The localizations of these average constant errors are shown by small encircled crosses.

It will be seen, therefore, that although by Ponzo's method the constant error in these two examples is the same, this error when determined by the usual method differs in the two cases. In the first example it is toward the right, in the second it is toward the left. In the first example the constant error is at an angle of 55.5 degrees from the upper part of the principal line, in the second it is at an angle of 260 degrees.¹ In each case the "angular" error does not lie within the angular limits which Ponzo sets as the direction or axis of the anatomical part.

An objection may be raised that the illustrated examples are isolated and extremes, and that they do not fairly represent the conditions with which Ponzo, in his work, and I, in my former paper, dealt. In a brief space it is not possible to discuss in detail the results which Ponzo has reported and illustrated, but examples in which similar, but perhaps not as extensive, differences are to be found are given in Ponzo's publications. At the same time it may be stated that the results on the individual points which were grouped in my previous article show at times as great deviations as in the two examples given here. Because of these variations in a number of tests on different days the average constant error for one point or for an anatomical segment is not large. Furthermore it should be stated that if the method of Ponzo

¹ Both roughly measured by a protractor showing angular degrees, and using the vertical axis above the stimulated point as zero degrees.

breaks down in cases of this character, which I cannot consider to be extremes, it is a method upon which little or no reliance can be placed, especially when broad generalizations are to follow from the account of the results.

Facts.—A question immediately arises regarding the accuracy of Ponzo's statement of the conditions encountered in localization tests when the adequacy of his method of dealing with the observations is disputed. Are suppositious general tendencies toward localizations along certain bodily axes, or along the courses of nerves, dependent upon his erroneous method of calculation of the constant error, or are they found to exist when the usual and more accurate constant error method is employed? An answer to this question is given in part in my previous paper, although in that article the results of the constant errors of localizations of touch stimuli for individual points were not given in full. The fact that my results on the individual points were not reported has led some to believe that my groupings into larger anatomical segments have concealed or balanced the constant errors, and that the apparent discrepancies between Ponzo's and my conclusions would disappear if I had dealt with the individual points. A further consideration of the groupings and the results from them will, however, serve to show that such is not entirely, if at all, the case. If similar groupings are made for all subjects the results should be directly comparable, regardless of the kinds of groupings, and it would make no difference how large or how small a grouping is made. That the constant errors are not the same in the two subjects, *A* and *C*, whose results were published, is evident from inspection.¹ At the same time it must be observed that with the groupings in the two series of the same subject, *A*, the constant errors were not always the same. Other results to which I may refer are those for the soles of the feet of these two subjects, on each of which anatomical part only one point of stimulation was used. The results of the two series of tests on subject *A* do not correspond, although the results with subject *C* have a fairly close correspondence with

¹ See Table V., page 120 of my previous article, *op. cit.*

the results of the first series on subject *A*.¹ In this connection attention may be called to the results obtained by another method of constant error estimation which I employed and which gave inconstant results. When the subject localized the first stimulation this localization was taken as the second point of stimulation, the second localization was taken as the third point of stimulation, etc. Subject *A* by this method, starting from a point on the mid-line of the body and on a level with the nipples, reached in 10 tests on one day "a point 8.5 cm. from the mid-line and 17 cm. below the first stimulation. . . . In a second experiment on a subsequent day in 10 tests the point was reached on the left 10 cm. from the mid-line and 16.5 cm. below the first stimulation. In a third series, a point was reached after 10 tests, 11 cm. from the mid-line, and 9 cm. below the first stimulus."² In relation to the primary points the general tendencies in these three tests are indicated by the angular relations of the average constant errors to the point on the mid-line. These are respectively 153, 148, and 129 degrees.³ The approximate amount of the angle of the ribs with the sternum at the original point of stimulation is approximately 85 degrees. These results tend to confirm what I shall now endeavor to show more accurately, namely, that the errors of localization of stimuli to definite points in certain anatomical segments

¹ It would not be justifiable to make further comparisons of supposedly similar points on different subjects at this time, for it is not possible to determine that the points were in all cases anatomically identically located. The subjects are no longer available (artists' models make up part of our city-to-city floating population) and anatomical comparisons cannot be made. The reason why this comparison cannot be made from my available records is because I selected for my former work points which were at definite distances from certain anatomical landmarks, such as the axilla, the umbilicus, the nipples, etc., but with the differences in lengths and girths of the bodies the points did not always correspond with respect to other bony landmarks and with the supposed courses of nerves. Especially in relation to the stimulated points on the thorax are these differences of importance, for a variation of one or two centimeters in the length of the chest would shift the location of a point from an intercostal space to a supracostal area, or vice versa. The recalculation of the individual points would not, therefore, be of any advantage towards the solution of the problem.

² *Op. cit.*, p. 121.

³ Protractor measurements.

do not correspond with the direction of the nerves, as Ponzo has contended.

Ponzo's¹ conclusions on this point refer especially to the localization of pressure and pain stimuli in the intercostal spaces. He has reported for three subjects results of localization of stimuli in the fifth, sixth, seventh, and eighth intercostal spaces, which are interpreted to indicate a localization in the direction of the intercostal spaces, with the further tendency to locate toward the end branches of the nerve which innervates the skin covering such a space. He subsequently added the conclusion that the errors of localization of sensations of warmth and of cold on other bodily parts correspond with the general direction of the superficial nerve trunks.² The value of these conclusions, if they should be found to be correct, is very great for anatomical workers, but greater for clinicians who, by the application of a few tests to show the constant error in the localization of pressures and temperature stimuli, would be enabled to discover in the living subject the course of the cutaneous nerves in different portions of the body.

The present series of tests were made upon an artists' model, Miss W., who is about 20 years of age.³ Special attention was paid to certain areas of the body in which the directions of the nerves are very constant, in order that the constant error tendencies might be considered in relation to the courses of these nerves. The areas which were investigated are as follows: (*A*) A point in the axillary line overlying the seventh intercostal space when the arm is lying fairly close to the body; (*B*) a point near the mid-line of the chest at the junction of the fourth intercostal space with the sternum; (*C*) a point on the mid-body line, at the level of the nipples; (*D*) a point on the anterior part of the thigh,

¹ Ponzo, M., 'Observations sur la direction des erreurs de localization dans les espaces intercostaux,' *Arch. ital. de biol.*, 1911, 56, 193-201.

² Ponzo, M., 'Studio della localizzazione delle sensazioni termiche caldo e freddo,' *Riv. di psicol.*, 1913, 9, 393-415.

³ In most of the tests I have had the assistance of Dr. Mildred E. Scheetz, who also in my absence carried out some of the tests which are here reported. The results obtained by her did not differ from those carried out by me more than those obtained by me on one day differed from those obtained on a subsequent day.

about half way from the knee and about midway between the middle and internal branches of the anterior cutaneous nerve of the thigh (branches of the femoral or anterior crural); and (*E*) a corresponding point on the lateral portion of the thigh, which is supposedly supplied by the lateral femoral cutaneous nerve. All of the nerves supplying these parts are relatively constant in direction, although in the living subject it is not possible to determine their exact courses.¹ Dissection shows them to be about as constant in location as any other nerves of the body, and they were selected instead of arm nerves because of the presumably lesser experience the subject would have in locating stimuli along their courses. It should not be supposed, however, that the location of skin areas in relation to the underlying nerves can be determined exactly, and that the selected points are definitely related to the supposed underlying nerve trunks. With respect to the points at the intercostal spaces, and *pari passu* the remark applies to the other locations, a slight amount of movement of the arm or a slight twist of the thorax will throw the superficial point out of its definite relation to the intercostal space, bringing it above a rib.²

The stimuli were given by means of a short brush, stiffer than one which I have previously used for light touch tests, and it is certain that not only was the superficial skin stimulated but also the underlying tissues. This would give results relating to the compound of touch and pressure stimuli, which corresponds well with the conditions in the work of Ponzo. Twenty tests were made at each point on one day, and the averages of the tests are considered here. At the same time it is possible to combine the tests on different

¹ The courses of these nerves may be learned from almost any good text-book of anatomy.

² This is a point which must be considered in dealing with the relations of localizations to underlying nerves. What for example shall we consider the nerve supply to the skin overlying an intercostal space to be? Is it from the nerve emerging in the intercostal space which the skin covers when the arm is held close to the side of the body? Or, is it the nerve of the space above, which the skin covers when the arm is raised above the head or in some cases when the arm is at a right angle to the axis of the trunk? In the present work the superficial assumptions of Ponzo have been followed, but not necessarily accepted.

days into suitable groups referring to the same point, and to make comparisons of the results.

Seventh intercostal space.—Two series of experiments were made on the left side, and one on the right, in the seventh intercostal space where the space meets the mid-axillary line. Twenty tests were made in each experiment. The results of the calculation of the constant errors in these experiments are as follows: On the left, 25.3 mm. upwards, 3.1 mm. toward the back of the body; and 4.0 mm. downwards, and 1.9 mm. toward the back of the body; on the right, 7.5 mm. upwards, and 14.1 mm. toward the front of the body. It will be noted that the error away from the axillary line, toward the front or back, differs in the experiments on the right and left sides, and it will also be noted that the errors in the two series on the left side differ with respect to the location of the stimulated point in relation to the upper and lower (cephalad and caudad) portions of the body. It is apparent that by the usual methods of determining the constant tendency there is not much agreement among the three experiments. With reference to the angles of the average constant error localizations in relation to the mid-axillary line it may also be said that in the three experiments the localizations are different. They are respectively 7° , 155° , and 61.5° .

At the times the tests were made the directions of the intercostal spaces in relation to the mid-axillary line were determined by laying a finger upon the skin overlying the space and after having pressed the finger into the space as closely as it would fit the outlines were marked upon the skin with a grease pencil. The center line between the two lines which were marked was taken to represent the direction of the space, and its angular direction in relation to the mid-axillary line was determined, using the portion of the latter above the point as zero degrees. In the three experiments which have been described the directions which were determined were greatly different, for they were 120° , 137° , and 122° respectively. At first glance there appears the probability of great error in the making of these measurements,

for it seems improbable that on the same subject the angle of the ribs should differ by as much as these measurements differ. To test the matter the subject was at a subsequent session measured a number of times, both by me and by an assistant. The grease pencil marks were obliterated after each record was taken and new marks were made for each determination. The results of the measurements are as follows: Right side, with the arm close to the body, 119° and 118° , with the arm abducted and held above the head, 114° and 131° , left side, with the arm at the side of the body, 130° and 120° , with the arm raised above the head, 128° and 125° . These measurements which were taken with extra care do not differ from those taken three months previously more than do the earlier corresponding measurements from one another. In other words it appears that the angular relation of the seventh intercostal space to the mid-axillary line is not constant, or that the errors of measurement are large. The former is what might be expected from what we know of the rib movements in connection with the acts of respiration. At the same time it should also be noted that the angular directions of the intercostal spaces vary according to the position of the arms. This is shown by the series of figures just given and is further demonstrated by the results of a series of measurements on other subjects on whom the angular measurements were taken by Dr. Scheetz. These measures are given in Table I.

This table shows clearly the variations in accordance with the positions of the arms, the averages for all completed series (two each on *A* and *B*, and one each on *C* and *D*) being 95° when the arm is held close to the body, 111° when the hand is placed upon the opposite shoulder, and 118° when the arm is raised above the head. These variations, it will be noted, are greater than those found with the subject on whom the present tests were made, and may partly be accounted for by differences in the shapes of thorax, and in the amounts of subcutaneous fat in the four subjects.

Assuming, however, that the angular measures first taken on our present subject (120° , 133° , and 122°) are sufficiently

exact, we may examine the results of the localizations by the method of Ponzo. When we draw the bounding lines to indicate the directions we find for the three series the following: I., In the direction of the space, 5 localizations, away from the direction of the space, 15 localizations; II., in the direction of the space, 8, away from the direction, 12; III., in the direction, 8, away from the direction, 12. In no case, therefore, did the subject show a constant tendency to localization in the direction of the space, as has been contended.

TABLE I

ANGULAR DIRECTIONS OF THE SEVENTH INTERCOSTAL SPACES IN RELATION TO THE MID-AXILLARY LINES

Asterisks denote that measurements were not made in these cases.

Subjects	Sides of Body	Arm Near Body	Hand on Opposite Shoulder	Arm above Head
A.....	R.	91	112	112
	L.	108	122	135
B.....	R.	109	120	121
	L.	78	117	106
C.....	R.	89	114	127
	L.	*	103	104
D.....	L.	95	83	107
	R.	126	*	*
E.....	L.	118	*	*

Fourth Intercostal Space.—One series of twenty experiments on a point in this space, on the right side four centimeters from the mid-line, gave an average constant error 11.8 mm. downwards, and 14.1 mm. toward the mid-line of the body. The angular relation of the space to the mid-body line was found to be approximately 90° . The angular location of the constant error is, therefore, within the boundaries set by Ponzo (45° to 135°). At a subsequent session measurements of the angular relation of the space to the mid-body line gave 78° on the right side, and 87° on the left side. In another subject the angular relation was 86° . It will be seen, therefore, that the error is close to the lower boundary of the angular limits, although within them.

When measured in relation to the boundary lines it was found that 14 of the localizations were within the boundaries

and 6 outside, although it should also be mentioned that only two of the localizations were between 0° and 90° , and the remaining 18 were in the space bounded by the 90° and 180° lines.

Mid-body Line at the Level of the Nipples.—Two tests of twenty experiments each were made with the right hand for localization and one similar test with the left hand for localization. These three tests show respectively the following constant errors: I., 7.8 mm. downwards, 15.2 mm. toward the left side; II., 0.9 mm. toward the head, 6.1 mm. toward the left; III., 6 mm. toward the head, 3.7 mm. toward the left. The results in the three series correspond as far as left-sided localization is concerned, but do not correspond with respect to cephalad or caudad localizations. Since we have no definite knowledge regarding the course of the nerves at this point beyond the general belief that the skin is probably innervated almost equally from both sides of the spinal cord, the results are negative. It should be said, however, that if we believe in an equilateral innervation there is no apparent reason for the left-sided localization constant error.

Anterior Thigh.—The location of the stimulated point has already been mentioned. The results of 200 experiments, 20 on each leg on each of five days, are given in the accompanying table (Table II.) which shows the average errors of localization, the constant errors centralwards or distalwards, and to the right or to the left. The results of the calculation of the same results by the rougher method of angular limits are also shown in Table III. It will be seen that the constant errors in the five series do not correspond. In one test the average constant error lies to the left, in another test it lies to the right; in one it is toward the abdomen, in another it is toward the foot. At the same time it will be observed that there are great variations in the localizations in relation to the angular measurements, and that, on the assumption of a direction of nerve from 355° to 175° , the constant error is located within the angular limits in only seven of the ten experiments. The totals of the 100 experiments on the right and the 100 experiments on the left show that the

general direction of localization is in the nerve direction, if we can use the method of angular limits for the determination of the constant error. This tendency to location in the supposed direction of the nerve is, however, not very large, for there is only a superiority of 50 per cent. in the localizations in the direction as compared with those at right angle to the direction (viz., 120 : 80).

TABLE II

AVERAGE AND CONSTANT ERRORS ON THE RIGHT ANTERIOR THIGH.
20 EXPERIMENTS ON EACH DAY

Constant errors calculated by the usual method.

	Serial Days					Averages
	1	2	3	4	5	
Av. error.....	24.3	17.5	12.0	20.0	17.0	18.2
C.E. \updownarrow	\uparrow 19.1	\uparrow 10.5	\downarrow 6.3	\downarrow 13.8	\downarrow 1.6	\uparrow 4.0
C.E. \rightleftarrows	0	0	\leftarrow 1.3	\rightarrow 5.3	\rightarrow 9.7	\rightarrow 2.8
C.E. degrees.....	0	0	168.5	159.0	99.0	35.0

AVERAGE AND CONSTANT ERRORS ON THE LEFT ANTERIOR THIGH.
20 EXPERIMENTS ON EACH DAY

Av. error.....	17.8	13.0	12.5	14.0	25.0	16.5
C.E. \updownarrow	\uparrow 3.3	\downarrow 2.8	\downarrow 4.8	\downarrow 2.7	\uparrow 4.0	\downarrow 1.5
C.E. \rightleftarrows	\leftarrow 2.8	\rightarrow 1.7	\leftarrow 2.1	\leftarrow 7.5	\rightarrow 0.2	\leftarrow 2.1
C.E. degrees.....	320.0	149.0	203.5	250.0	3.0	235.0

TABLE III

CONSTANT ERRORS DETERMINED BY METHOD OF ANGULAR LIMITS

Right Side

Serial Days	Direction of Nerve	Opposite Direction
1	13	7
2	11	9
3	14	6
4	10	10
5	15	5
—	—	—
Totals.....	63	37

Left Side

1	10	10
2	8	12
3	12	8
4	15	5
5	12	8
—	—	—
Totals.....	57	43

TABLE IV

AVERAGE AND CONSTANT ERRORS ON THE RIGHT LATERAL THIGH.
20 EXPERIMENTS ON EACH DAY

Constant errors calculated by the usual method.

	Serial Days					Averages
	1	2	3	4	5	
Av. error.....	17.0	13.3	14.0	33.8	54.5	26.5
C.E. ↓.....	↑3.8	↓2.8	↑8.5	↓5.2	↑10.3	↑2.9
C.E. ⇌.....	→9.1	←3.5	→3.7	→34.1	→50.6	→18.8
C.E. degrees.....	67.0	231.5	24.0	98.5	78.5	82.0

AVERAGE AND CONSTANT ERRORS ON THE LEFT LATERAL THIGH.
20 EXPERIMENTS ON EACH DAY

Av. error.....	22.8	14.8	16.0	23.3	28.3	21.0
C.E. ↓.....	↓15.3	↑2.8	↑2.8	↑5.9	↑4.2	↑0.1
C.E. ⇌.....	←12.3	←7.5	←5.7	←8.8	←22.8	←13.4
C.E. degrees.....	219.0	290.5	297.0	287.0	280.0	270.0

TABLE V

CONSTANT ERRORS DETERMINED BY METHOD OF ANGULAR LIMITS

When a point has been on a line it has been calculated as half each way.

<i>Right Side</i>		
Serial Days	Direction of Nerve	Opposite Direction
1	12	8
2	9.5	10.5
3	10.5	9.5
4	0	20
5	0	20
Totals.....	32	68
<i>Left Side</i>		
1	10.5	9.5
2	5.5	14.5
3	7	13
4	3.5	16.5
5	5	15
Totals.....	31.5	68.5

Right Lateral Thigh.—The nerve supplying this portion of the body is very constant in direction in cadavers, following an almost straight line from the crest of the ileum to the middle of the knee, in other words from 0° to 180°. The re-

sults of five tests on different days on the two legs on the selected points, 200 experiments in all, are given in Table IV., and the results of the calculation by the method of angular limits are given in Table V.

In these tables it will be observed that the constant errors in the individual tests differ greatly. In some there is an apparent tendency to locate toward the pelvis, in others toward the knee; in one there is a tendency to locate toward the dorsal surface and in the other nine toward the anterior surface of the leg. The angular relations of the constant error determinations to the supposed nerve course in these ten series greatly differ, ranging from 24° to 231° on the right leg, and from 219° to 297° on the left leg. Within the artificial angular limits there is only one constant error direction on the right and none on the left side, four on the right and five on the left being outside of the supposed angular directions.

In only three tests is there a predominance of localizations in the direction of the artificially set angular limits, and in the other seven tests there is a superiority of localization in the spaces at right angle to the artificially set directions. For the total of ten tests, therefore, there is a superiority in direction away from the space amounting to over 100 per cent.

Summary.—The method of calculation of constant error by angular limits is too inexact to warrant its use except as a possible qualitative method for preliminary work. The constant error tendency in the five locations selected for the present series of tests is in only one place in the supposed direction of the innervating nerve, whether this tendency be measured by the usual and more exact means or by the method of angular limits used by Ponzo. Conclusions regarding the constancy of direction of constant errors must be radically changed to conform to the facts.

One possible objection may be raised to the present series of results. This is that they have been obtained with only one subject. This objection loses its force in view of the widespread generalizations which have been made, for it

becomes apparent that if the conclusions set forth by the Italian investigator are not applicable to other than his own subjects they cannot be accepted as general. I am not willing, however, to admit that Ponzo's conclusions have been founded upon the utilization of the best methods, and in fact it is amply demonstrated that the method employed by him is so faulty that its use is unjustified.