STUDIES IN SENSATION : OBSERVATIONS ON THE LOCALIZATION OF THE SENSATIONS OF TOUCH AND PRICK

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The sensory experience commonly referred to as a prick is of great interest, not because of its intrinsic importance, but because of the information about sensory mechanisms which can be obtained from its study. In this paper observations on the ability to localize the sensation of prick are reported and compared with the power of touch localization.

The elicitation of the sensation of prick by means of mechanical stimulation with a needle has the disadvantage that the needle must first make contact with the skin, so that a sensation of touch may confuse observation of the prick. Bishop (1943) devised a means of stimulating the skin by an electric spark; he showed that stimulation at certain points gave rise to a sensation of touch while at other points on the skin a prick was felt. Repetitive stimulation of a "touch spot" gave rise to a sensation of pressure, whereas repeated stimulation of a "prick spot" caused pain. This method of stimulation of discrete spots by an electric spark has been employed in the present study.

Elithorn, Piercy, and Crosskey (1952) studied the ability of patients to localize a touch stimulus applied to the fingers before and after the operation of leucotomy. They showed that before operation localization of touch follows a conceptual pattern of the hand in which all points on the skin are not equipotential. Errors are not made and referred at random but in accordance with this conceptual pattern. The observations which are reported here on the power to localize the sensations of touch and prick will be discussed in the light of the findings of Elithorn and others.

Technique

The observations were made on the dorsal and palmar aspects of the middle phalanges of 22 normal subjects (nurses and medical students). The hand was fixed in a plasticine mould, and eight needles were adjusted so that they made imperceptible contact with the radial or ulnar half of the middle phalanx of each of the four fingers. For testing "prick spots" the dorsum of the fingers was used and for "touch spots" the palmar aspect. This

was done because "prick spots" are more dense on the dorsum and "touch spots" on the palmar aspect of the fingers (Bishop, 1943), hence it was considered that a fairer comparison could be made by this means rather than by comparing the same skin area with a different density of "prick" and "touch" spots. The needles were adjusted so that they lay over the appropriate type of spot.

An electric spark, produced by a condenser discharge (Fig. 1), was supplied to each needle as required. The

FIG. 1.—Circuit for production of electric spark by means of condenser discharge through a car induction coil.

hand was screened from the subject, and he was given a diagram of a hand on which to mark his observations. He was instructed to indicate which finger was stimulated, and whether it was the radial or ulnar side. He was not required to indicate the exact site, nor how proximal or distal the stimulus was. Stimuli were applied in a random order, two to the radial and two to the ulnar side of each finger of both hands, making a total of eight stimuli each for touch and prick. To eliminate the possibility of any learning effects, in half the subjects first the palmar aspect (touch) then the dorsum (prick) of the one hand was tested, followed by the other hand in a similar order, while in the other half tests were started on the dorsum of one hand followed by the palmar aspect with the same order in the opposite hand.

Results

Incidence of Errors.—An equal number (704) of stimuli was applied to both touch and prick spots, but as is shown in Table I there were only 14 touch errors but 190 prick errors. Applying a χ^2 test to these figures gave $\chi^2 = 8.68$ which is highly significant ($P > 0.01$). It immediately appeared

therefore, that the ability to localize the sensation of prick was inferior to the power of touch localization.

Errors at Different Sites of Stimulation.—When the incidence of errors at the different sites of stimulation was studied (Table I), further differences

TABLE I
NO. OF ERRORS OCCURRING AT EACH STIMULUS SITE
IN 22 SUBJECTS

		Sites of Stimulation								Total
		2R	2U	3R	3U	4R	4U	5R	5U	
Touch		6	11	14	35	24	24	14	15	143
Prick		20	16	17	36	28	37	12	24	190

2, 3, 4, 5 indicate index, middle, ring, and little fingers respectively, R=radial side, U=ulnar side in all Tables.

between touch and prick became apparent. In both instances the distribution of the errors could be shown by the χ^2 test to be unlikely to have arisen by chance (touch $\chi^2 = 41.68$, $P > 0.01$; prick $\chi^2 = 31.86$, $P > 0.01$), but the distribution between the various sites of stimulation did not follow the same pattern for both types of sensation. In the case of touch, the number of errors rose from both margins of the hand to reach a peak at the ulnar side of the third digit (the middle finger); in the case of prick, however, there were marginal peaks on the radial side of the index finger and the ulnar side of the little finger and a central plateau extending over the ulnar side of the middle finger and the radial and ulnar sides of the ring finger. This is unlikely to have arisen by chance as the same pattern was seen on each hand. Hence, though both touch and prick errors appeared not to be distributed by chance but according to a pattern, the pattern was not the same for the two types of sensation.

Sites of Reference of the Errors.—Tables II and III show the sites to which each erroneously

TABLE II
SITE TO WHICH TOUCH ERRORS WERE REFERRED FROM
EACH SITE OF STIMULATION IN 22 SUBJECTS

Sites of Stimulation	Sites of Reference of Errors							
	2R	2U	3R	3U	4R	4U	5R	5U
2R	—	6	—	—	—	—	—	—
2U	8	—	1	2	—	—	—	—
3R	1	2	—	8	2	1	—	—
3U	—	1	22	—	5	—	—	—
4R	—	—	4	7	—	13	—	—
4U	—	—	2	2	18	—	2	—
5R	—	—	—	1	—	1	—	12
5U	—	—	—	—	1	—	14	—

localized stimulus was referred for touch and prick respectively. Inspection of these Tables shows that the errors were not referred in a random fashion,

TABLE III
SITE TO WHICH PRICK ERRORS WERE REFERRED FROM
EACH SITE OF STIMULATION IN 22 SUBJECTS

Sites of Stimulation	Sites of Reference of Errors							
	2R	2U	3R	3U	4R	4U	5R	5U
2R	—	17	1	1	1	—	—	—
2U	10	—	—	6	—	—	—	—
3R	—	1	—	10	5	1	—	—
3U	—	—	21	—	8	7	—	—
4R	—	—	—	7	—	21	—	—
4U	—	—	1	5	29	—	1	1
5R	—	—	—	—	1	6	—	6
5U	—	—	—	—	—	1	22	—

but were distributed according to a pattern. In every instance for both touch and prick, the majority of errors were referred to the wrong side of the stimulated finger. In the case of touch, in all but two instances (2U, 3U), more errors were referred to either of the two immediately adjacent sites than to more remote sites, while for prick this was so in all but one instance (2U). In this regard the findings differ from those of Elithorn and others (1952) who found that in the majority of instances more errors were referred to the corresponding side of the adjacent finger, that is to a position two removed from the site of stimulation, than to the wrong side of the stimulated finger.

Hence the pattern of distribution of errors was seen to be, first, to the wrong side of the stimulated finger, secondly, to the adjacent side of the next finger and, thirdly, to the corresponding side of the adjacent finger and rarely to more remote sites.

Type of Error.—Two types of error in reference to the site of stimulation may be considered, namely, those arising following stimulation of the ulnar side of a finger and those following radial stimulation. Table IV shows a predominance of

TABLE IV
NO. OF FINGER AND SIDE ERRORS IN RELATION TO
SITE OF STIMULATION IN 22 SUBJECTS

			Finger	Side	Total
Prick					
Ulnar ..	..	..	31	93	124
Radial..	..	..	23	70	93
Total	..	..	54	163	217
Touch					
Ulnar ..	..	..	23	73	96
Radial..	..	..	19	51	70
Total	..	..	42	124	166

errors following ulnar stimulation over those following stimulation of the radial side of a finger for both touch and prick. Errors may also be considered in accordance with their site of reference.

Thus, errors may be referred either to the wrong finger or to the wrong side of a finger. The double error of wrong finger and wrong side is considered as two separate errors. Table IV shows that side errors are much more common than finger errors for both touch and prick and, moreover, that both types of error occur more frequently following stimulation of the ulnar side of a finger than the radial. The sites of reference of the two types of error do not appear to follow the same pattern (Table V).

TABLE V
SITES OF REFERENCE OF FINGER AND SIDE ERRORS
IN 22 SUBJECTS

	Sites of Reference of Errors							
	2R	2U	3R	3U	4R	4U	5R	5U
Touch Finger	1	3	7	12	8	9	2	—
Finger	8	8	25	16	24	15	16	12
Prick Finger	—	1	2	19	15	15	1	1
Side	10	18	22	18	38	28	23	6

Finger errors are referred almost exclusively to the digits 3 and 4, whereas side errors, though showing a preference for digits 3 and 4, are frequent in digits 2 and 5 also. This feature applies to both touch and prick errors.

Direction of Errors.—The direction of reference of finger errors has been considered in relation to digits 3 and 4, in each of which there is a freedom to refer the error in either a radial or an ulnar direction. Table VI shows that for both touch and prick in the

TABLE VI
DIRECTION OF REFERENCE OF FINGER ERRORS
FOLLOWING STIMULATION OF DIGITS 3 AND 4 IN 22
SUBJECTS

	Referred Ulnarly	Referred Radially
Digit 3		
Touch	15	4
Prick	21	1
Digit 4		
Touch	2	15
Prick	2	13

case of digit 3 there is a marked tendency to refer stimuli in an ulnar direction. In the case of digit 4, the opposite tendency prevails. The majority of stimuli are referred towards the radial side of the hand. Thus it appears that when there is freedom of choice, errors tend to be referred towards the middle two fingers, and this tendency is seen to obtain for both prick and touch errors.

Discussion

These studies on the ability to localize the sensations of prick and touch may first be compared

with those of Elithorn and others (1952) on touch localization. It should be remembered that the experimental methods were similar but not identical in the two series. Elithorn and others used a blunt point to test touch but in this study an electric spark was employed. Elithorn's subjects plotted their results on the hand of an observer, and not on a chart. The number of subjects was the same in both series, but Elithorn was able to examine each many times over a period, and hence has more raw data to analyse. His subjects were, however, admittedly not normal from the psychiatric viewpoint though "most were free from neurological lesions".

The general pattern of the distribution of touch errors in relation to the site of stimulation was the same in both series with a maximum incidence on the ulnar half of the middle finger. The greater liability to error when the ulnar side of the finger was stimulated and the predominance of side errors over finger errors were also features of both series. It was with regard to the sites to which errors were referred that a difference appeared. Elithorn and others found that an error was most commonly referred to the corresponding side of the next finger, rather than to the opposite side of the same or adjacent fingers. In the present series, however, there was a clear tendency to refer errors first to the opposite side of the same finger, secondly to the adjacent side of the next finger, and only thirdly to the corresponding side of the adjacent finger. In both series, however, the results were clearly distributed according to a conceptual pattern and not by chance, but the type of pattern revealed differed in the two series.

When the results for touch and prick are compared in the present series interesting differences become apparent. The superiority of tactile localization over the localization of the sensation of prick is clearly demonstrated. The idea that the sensation of prick is simply touch plus a localized pain is therefore not supported, for, were this so, one would expect the power of localization to be equally good. A further difference is in the abrupt rise in the incidence of errors at the marginal sites of the hand, that is, the ulnar side of the fifth digit and the radial side of the second digit. This was found for both hands separately, hence is unlikely to have been an artefact, and is in contrast to the finding in the tests on touch localization. This suggests that prick is dealt with separately from touch not only with regard to the immediate appreciation of its distinctive quality, but also with regard to the recognition of its site of origin.

That the mechanisms which enable us to recognize a sensation are separate from those subserving its

localization is clearly demonstrated by the abolition of the power of localization without impairment of appreciation of touch in lesions of the parietal cortex. It might be thought, however, that though the mechanisms for the appreciation of the various modalities of sensation are different, all localization is carried out by a single mechanism fed by information from the primary sensory areas. The degree of accuracy of localization achieved for each modality would depend on the amount of sensory information supplied to the localizing mechanism.

The differences in the incidence of errors of localization of the sensations of touch and prick as shown in this study, however, were not only of degree but also of kind. Prick was not only less accurately localized, but the incidence of errors followed a different conceptual pattern showing peaks at the margins of the hand as well as the centre. A point in the skin did not therefore have the same "value" for the localization of both touch and the sensation of prick. It would seem, therefore, that the mechanism underlying the power of localization is not simple but complex, and that separate

mechanisms subserve the localization of touch and the localization of the sensation of prick. Differences in the powers of localization of various sensory modalities might well, therefore, be sought in discrete lesions of the parietal lobe.

Summary

Localization of the sensation of touch is superior to that of prick.

Both the incidence of errors at each site of stimulation and the way in which errors are referred appear to follow a conceptual pattern, but the pattern is not identical for touch and prick sensation. This suggests that the localization mechanism for the sensation of prick is distinct from that for touch.

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