

Reports

Space-Time Relationships in Somesthetic Localization

It has been suggested recently that the representation of somesthetic space depends on temporal patterns of neuronal discharge in the parietal association areas of the cerebral cortex (1). This suggestion was based on the discovery that there are neurons in these areas which may be aroused from any of several points on the periphery, but with different latencies. It is likely therefore, that time and space should be interchangeable to some degree, and that increasing the temporal separation of two stimuli should decrease the spatial separation necessary for them to be judged as in different places. Such is actually the case for touch. It is well known that the two-point threshold (stimuli simultaneously presented) is considerably greater than the error of localization (stimuli successively presented) (2). But the temporal relationships have not been studied in detail, as is necessary if the neurophysiological and psychophysical data are to be correlated. The experiment reported here is a step in that direction (3).

The minimum separation of two stimuli to the skin which led them to be judged to be in different places was determined for each of several temporal intervals between them. The stimuli, electric square waves of 0.5-msec duration, were presented to the forearms of two subjects through silver-silver chloride wick electrodes. The stimuli were generated by a "two-shot" stimulator built in the department of physiology and biophysics, University of Washington. Intervals, from the end of pulse one to the be-

ginning of pulse two, of 0.1, 1.0, 10.0, 100.0, and 1000.0 msec were used. Since the more distal of the two stimuli was always the second pulse, these intervals are about 2.1, 3.0, 12.0, 102.0, and 1001.0 msec when allowance is made for the extra conduction time. Four determinations of spatial separation were made for each interval on each subject at a single sitting, using the "up and down" method (4). Each subject had four sittings, with the different intervals given in balanced order, so that each threshold is based on 16 measurements. Considerable care was used to insure pure pressure stimulation, painful spots being discarded, and the intensity of stimulation was adjusted each time an electrode was moved to maintain a moderately strong pressure sensation. Subjects' reports consisted either of "same place" or "different place," because at the longest intervals the duality of stimulation was evident. Apparent movement was sometimes observed but did not interfere with the judgments.

The data are given in Table 1. If the shortest interval is taken to represent the two-point threshold and the longest is taken to approximate the error of localization, the data are in agreement with the older research. There is significant interaction of space and time, and increasing the interval reduces the separation necessary to produce the report of "different place."

The question now arises whether the psychophysical and neurophysiological data are consistent. If allowances are made for species differences and for the effects of anesthetics, the answer is in the affirmative. Amassian's "blocking" effects for the AAP (association-area positive response) extend over as many as 600 msec and are consistently noted below 150 msec. In the experiment reported here, the region of most rapid change in spatial threshold lay between 10 and 1000 msec, with only a slight change, if any, between 2 to 10 msec. The error of localization is approximated at about the interval necessary for blocking to be ineffective. The blocking could account for the lack of fine discrimination because the necessary information does not reach the parietal association areas.

There are possible alternative explana-

tions of the psychophysical data. Some years ago Boring suggested that the difference between the two-point threshold and the error of localization could be due to the spread of excitation in the skin (he had mechanical stimulation in mind) (5). He did not have precise temporal data available, and the present data, because of the relatively large critical intervals, do not favor a peripheral explanation. The same spread-of-excitation argument could be extended to the relay nuclei and the primary sensory cortex, however. Isomorphic theories of space perception have been popular, and if two-point tactual discrimination is considered to be based on two regions of excitation in the primary cortex, it may also be that temporal separation permits better differentiation of these regions. This would imply that the "sharpening" process imputed to some sensory systems is improved by the delay of one afferent process, an implication that is not borne out by experimentation on vision (6). When it is considered in addition that lesions in the parietal association areas may lead to a severe deficit in somesthetic perception (7), the suggestion that space perception in the pressure sense arises from the translation of spatial patterns in the primary sensory cortex into temporal patterns in the association areas has both plausibility and appeal. If this suggestion should prove correct, it will be of considerable aid in clarifying the problem of the neurophysiological basis of perception.

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References and Notes

1. V. E. Amassian, *J. Neurophysiol.* 17, 39 (1954).
2. See, for example, E. G. Boring, *Sensation and Perception in the History of Psychology* (Appleton-Century, New York, 1942), pp. 484 ff.
3. This experiment was performed while I was spending a sabbatical year as research associate in physiology and biophysics at the University of Washington School of Medicine, Seattle.
4. J. P. Guilford, *Psychometric Methods* (McGraw-Hill, New York, ed. 2, 1954), p. 114.
5. E. G. Boring, *Am. J. Psychol.* 42, 446 (1930).
6. Vision does not behave the same as somesthesia. M. Leyzorek, [*J. Exptl. Psychol.* 41, 364 (1951)] found no time dependence for visual acuity up to 13 sec.
7. J. P. Evans, *Proc. Assoc. Research Nervous Mental Disease* 15, 331 (1934).

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Enzymatic Deficiency in Primaquine-Sensitive Erythrocytes

Primaquine, 8-(4-amino-1-methylbutylamino)-6-methoxyquinoline, induces intravascular hemolysis in about 10 percent of Negroes, but rarely in Caucasians (1). This hemolysis is due to a defect of the red blood cells (2), is

Table 1. Minimum separation, in centimeters, judged as "different place" by subjects F.N.J. and M.H.J.

Interval (msec)	F.N.J.		M.H.J.	
	Mean	S.D.	Mean	S.D.
2.1	11.0	1.4	11.8	1.2
3.0	10.6	.5	10.3	1.4
12.0	10.2	1.0	10.9	1.0
102.0	7.1	1.4	7.7	2.8
1001.0	4.5	.8	3.0	.9