Archives of Neurology, **40**, 548-551. (1983)

Localization Without Content

A Tactile Analogue of 'Blind Sight'

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• We examined the ability of a patient, who had a cerebral lesion involving the left posterior hemisphere, to identify and to localize stimuli applied to her "deafferented" right upper limb. We observed a functional dissociation between localization and identification in both performance and subjective report. This finding may be a tactual analogue of "blind sight."

***(Arch Neurol* 1983;40:548-551)**

In the sense of sight, studies have demonstrated that stimuli can be localized in the absence of striate cortex or, at least, when stimuli are given, within that region of the visual field that is assumed to be blind according to conventional perimetry.[1,2,3] In this situation, the anatomo-physiologic basis for a dissociation between identification and localization processes has been proposed[4] Comparable evidence for such a dissociation in other senses has not, to our knowledge, been reported. Therefore, data are presented that address the problem of localization of tactile stimuli on a "deafferented" hand.

Accepted for publication Nov 19, 1982.

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Read at the Nato Advanced Study Meeting on Ethology and Neuropsychology. Erice, Italy, May 1950.

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REPORT OF A CASE

A 52-year-old, right-handed woman had been referred to the Neurological Hospital, Lyon, France, for headache and reading difficulties. A carotid angiogram revealed an arteriovenous malformation on the dura mater around the left occipital lobe. The lesion was extracranial, and neuronal structures were probably intact. An obstruction of the nourishing artery, branching from the external occipital artery, was successfully carried out by an embolus introduced by catheterization of the external carotid artery. Unfortunately, some residual thrombotic material escaped from the tip of the needle and eventually obstructed the left posterior parietal artery. The results of this accident were a softening of the parietal area clearly shown by the computed tomographic (CT) scan (Fig 1).

The neurologic signs included an incomplete right-sided hemianopia, hemianacusia of the right ear, and right-sided hemianesthesia, all of which persisted for several years. The neurologic sequelae also included a mild conduction-type aphasia, ideational apraxia, dyscalculia, and right-left disorientation. All these symptoms improved considerably during the ensuing weeks. In spite of the extent of the lesion, there was no sign of optic ataxia in the intact visual field.

The tactile deficit is so severe that the patient may cut or burn herself without noticing it. The trigeminal area is involved, and the patient observed that she often forgets morsels of food between her right cheek and gums. The leg is also involved: the patient has twisted her ankle and missed steps when going up stairs. She is now able to distinguish hot from cold water. She has very little motor deficit; tendon reflexes are normal and symmetric.

The sensory and motor status of both arms was systematically examined, including tests of joint position sense, two-point discrimination, size and shape discrimination, visually guided pointing, finger tapping and the ability to reproduce active finger movements and to synchronize simultaneous left and right finger movements. It should be noted that the motor status of the deafferented hand was normal. Tapping with the right hand was possible as long as the patient watched her index finger or listened to clicks triggered by her finger tapping, but it became arrhythmic without visual or auditory feedback. Joint position sense and two-point discrimination were absent. Nevertheless, gross size discrimination was achieved by repeated, active palpation of the stimuli.

From the electrophysiologic point of view, the Ml, M2, and M3 electromyographic (EMG) responses to sudden stretch[5] of the deafferented wrist were normal. Recording of somatesthetic evoked potentials showed that the parietal components (N20, P27, P45) were absent following stimulation of the right index and middle fingers, whereas the frontal components (P22, N30) were present and even enhanced over the damaged hemisphere (see Mauguière et al[6] for a detailed report of these results)

EXPERIMENTAL PROCEDURES

Experimental procedures followed three steps. First, response to calibrated static pressure on the skin of the upper limbs was tested with the Toulouse-Vaschide esthesiometer.[7]

Second, 18 spots were marked on the palmar surface of the hands as localization targets (Fig 2). There were three trials for each target and the targets were presented in random order. The blindfolded patient was first asked, in a single ballistic movement (without correction at the end of the trajectory), to point with her deafferented hand to targets on the intact left hand then, with the left hand, to targets on the deafferented hand. The experimenter touched each target for 1 s at a time, alerting the subject with the word "here." Ten false trials, in which the examiner said "here" without touching a target, were

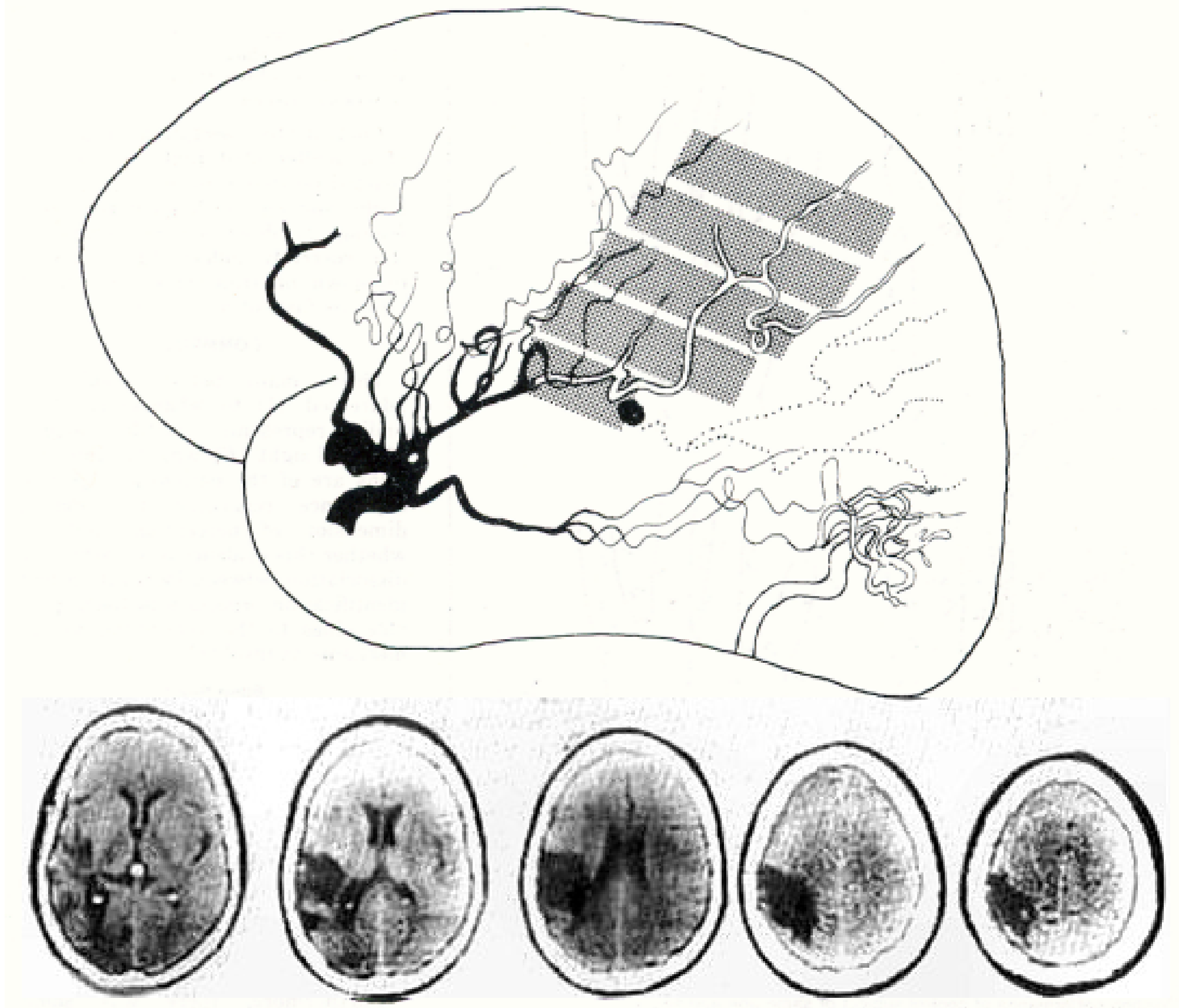

Fig 1.—Reconstruction of lesion according to five computed tomographic scan slices at bottom. In drawing of left hemisphere, black lines indicate normal arteries (anterior cerebral artery not completely drawn for sake of clarity); dotted lines, revascularization through dorsal arteries; white lines, thrombotic parietal artery. In occipital region, arteriovenous angioma is shown.

randomly interposed in each series of 54 stimuli. The patient's performance was filmed and her spontaneous comments recorded. Errors of localization were plotted on a tracing of the subject's own hands (Fig 2, top). A control subject of the same sex and age group was examined in a similar manner (Fig 2, bottom).

Third, moving stimuli were applied (esthesiometer, cotton wool) to both limbs at varying speeds (slow and fast) and directions (longitudinal and transverse).

RESULTS

Normal responses to static pressure were obtained from the intact left arm. In contrast, there was a complete absence of response, even to the strongest pressure, from the deafferented right arm, in a region extending from finger tip to a narrow band below and around the elbow articulation.

However, when this examination was repeated in subsequent sessions, after the patient had carried out the localization test described as follows, she was progressively able to detect static pressure as an "event" of which she had been totally unaware in the initial tests.

The patient's localization responses to the 18 targets (54 pointing responses) on the palmar surface of the hands were, in general, less accurate than those of the control subject (Table; cf Fig 2, top and bottom).

The Table shows that 92% and 90% of the pointing errors, on the left and right hand, respectively, fell within a range of 20 mm in the control subject, whereas 40% and 26%, respectively, of errors fell within the same range in the patient with a deafferented right arm. It is worth noting, however, that none of the ten false trials on the deafferented hand evoked a response. This means that every pointing movement of the normal left hand was apparently triggered by stimulation of the insentient right hand.

An additional feature of the patient's performance was the different pattern of error on the two hands, as well as her spontaneous comments during the experiment. When pointing to targets on the normal left hand, the patient showed systematic centrifugal errors with respect to the palmar center. In the reverse condition, when pointing on the deafferented right hand, the subject produced systematic centripetal errors.

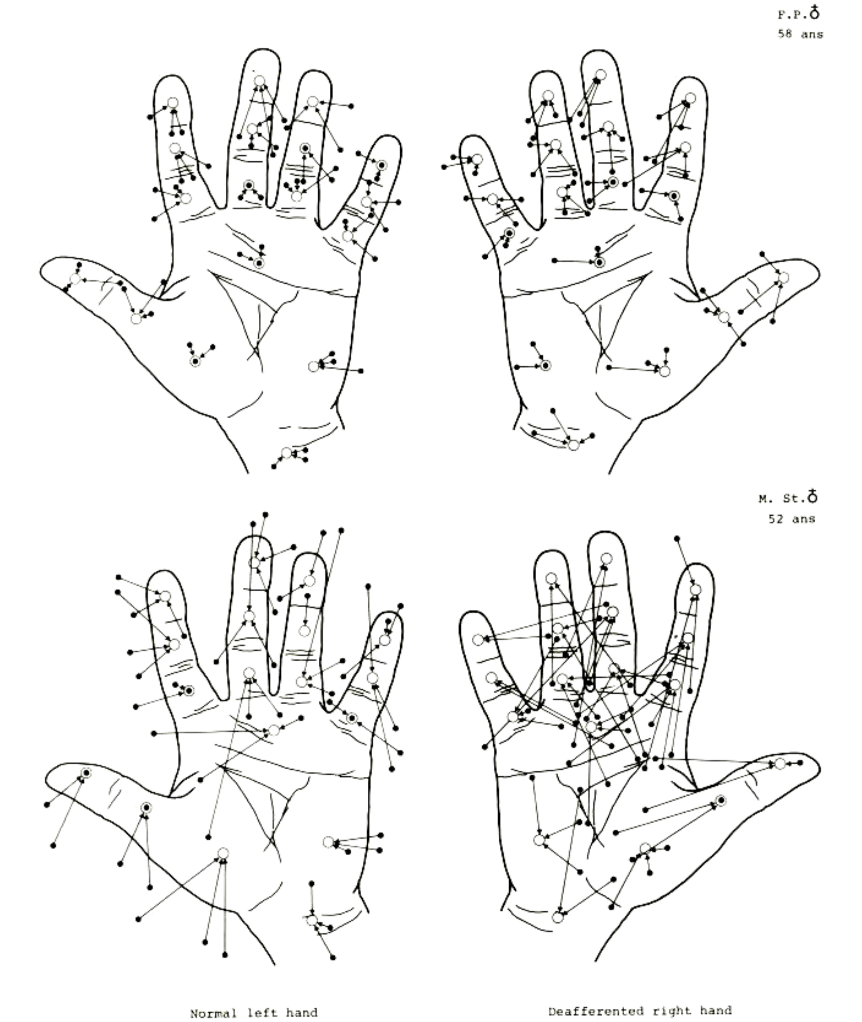

Fig 2. —**Bottom**. Pointing performance of the patient M.St. on her left normal hand (left) and on her deafferented right hand (right). Three stimulations were randomly distributed on each of 18 positions marked with circle. Black points and arrows indicate amount and direction of errors **Top**. Pointing performance of a control subject F.P. of same age and sex

Number of Cumulative Pointing Errors*

Hand	Range, cm				No Response to Stimulus	Response to False Trial
	≤1	≤2	≤3	≤6		
Control subject L	18	5O	54	54	0	0
R	14	49	54	54	0	0
Patient L	6	22	38	51	3	0
R	3	14	23	48	6	0

* For example, of the patient's 38 left-hand responses that were within 3 cm of the stimulus point, 22 were within 2 cm; only six of these were as close as 1 cm to the stimulus point

The patient's spontaneous observations were particularly informative. When pointing on the intact hand, the patient responded normally without comment. In the reverse condition, when pointing on the deafferented hand, she followed the instructions for the first few trials and then spontaneously interrupted the examination to express her astonishment. Her comments, despite traces of residual dysphasia, were very apposite, as shown in the following three samples:

But I don't understand that! You put something here. I don't feel anything and yet I go there with my finger. How does that happen?

I would like to understand, because, eventually, if I do not feel I should not be able to feel it either. Why do I see it? I "hear" that one.

Well' I cannot say what it is, but I know that there is a place that you are going to. But it's such a little thing, if you like. It's so tenuous, tenuous.

Contrary to expectation, in the case of a deafferented limb, the patient reacted positively to moving stimuli. Light moving touch gave rise to a feeling she described as "scraping." She correctly judged the direction (up-down or transverse) and speed (slow or fast) of movement.

COMMENT

Three main points should be addressed: (1) to what extent this finding represents a tactile analogue of "blind sight"; (2) what the implications are of the patient's subjective experience regarding the spatial dimension of perception; and (3) whether this evidence of a pathologic dissociation between localization and identification processes in touch provide clues to the underlying neural mechanisms involved.

Blind Sight

The similarities between our data and the phenomena recorded in the literature as blind sight are patent. To begin with, there was a clear-cut distinction between localization and identification; despite our patient's inability to detect static pressure on the skin, she was able, to her own considerable surprise, to point approximately to the locus of stimulation.

Furthermore, there was some capacity for gross size discrimination; the patient with blind sight is capable of coarse pattern discrimination[1-3] in the blind field, and our patient could detect gross differences in the size of objects palpated by the deafferented hand.

Also, there was evidence of improvement with practice; improvement of residual visual function has been reported in both monkey[8,9] and man.[10,11] After several sessions of the localization test, our patient's ability clearly improved. She became able to detect a localized but unidentified event.

There appeared to be a difference, however, in the results obtained in the tactual as compared with the visual modality in that there was no need to use a "forced choice" paradigm to obtain a response from our patient, whereas the "guessing mode" has been considered necessary to elicit blind sight. This apparent difference may stem from a change in experimental procedure. It is possible that, in our case, prior testing on the intact hand might have induced quasiautomatic pointing on the deafferented hand. After prior experience of pointing to a target on the intact hand, our patient did not hesitate to do likewise on the deafferented side before she herself was struck by this anomaly. We should also note that our patient was remarkably cooperative and attentive.

Also of interest in this context is a study by Volpe et al[12] of four patients with unilaterally impaired somatosensory function that included a loss of appreciation of joint proprioception and touch discrimination in the deafferented hand. All of them were able to locate, with a movement of the thumb, places on the deafferented hand analogous to those stimulated on the normal hand. The authors therefore concluded that spatially oriented movements are possible in the absence of proprioception. Inspection of their data, however, reveals that two of the patients were able to point accurately (in 28% and 25% of the trials, respectively) to places stimulated on the deafferented hand itself despite the clinical impairment of touch discrimination.

Patient's Perceptions

Our patient's comments during testing had interesting implications with regard to the content of her experience when attempting to respond to tactile stimulation of the deafferented limb.

Her first comment explicitly introduces the notion of localization without content. Her second comment reflects the strangeness of her experience and her resort to multimodal expressions (feeling, seeing, hearing) in attempting to describe it. Her third comment emphasizes the motor support for her localization responses and the tenuous nature of these unfamiliar sensations associated with them. Our patient apparently learned to use these sensations as attentional cues signaling the occurrence of stimulation at a given location.[11] "Learning" of this kind could explain the improvement in her ability to detect static pressure. These comments offer striking similarities to those of patients with blind sight as reported by Weiskrantz.[13]

Neural Mechanisms

From the neurophysiologic point of view, the dissociation between detection of movement and perception of static pressure observed in our patient (also discussed by Bender[14]) implies a separate mapping of static and dynamic tactile information in man, as has already been established in the monkey.[15] This finding clearly deserves further study in light of recent microelectrode mapping experiments showing that the classic primary somatosensory cortex in the monkey consists of as many as four separate body representations. The major input to area 3b is provided by cutaneous receptors signaling light touch whereas input from deep receptors predominates in areas 1 and 2.[16]

Turning now to the problem of the putative neural support for the dissociation between location and identification processes in the tactual modality, we are limited, as yet, by our rudimentary knowledge of the subcortical and cortical processing of somatesthetic afferents, as compared with the steadily increasing understanding of the multichanneling of visual afferents.[17,18] Several possible hypotheses are raised by our data. Localization was achieved either by some sparing of precentral sensorimotor cortex or by subcortical processing mechanisms. The second somatesthetic area (S2) or the supplementary sensory area may also have been involved. Of these, the contribution of S2 seems unlikely on the basis of the CT scan data, which suggest complete destruction in the depth of the sylvian fissure where wrist and hand are represented. Some sparing of precentral sensorimotor cortex, however, cannot be ruled out; the enhancement of the frontal components of the somatesthetic evoked potentials associated with an absence of its parietal components points in this direction.[6] But the possible role of the supplementary-sensory area is also particularly interesting in light of recent evidence concerning the functional properties of this hitherto uncharted area.[19]

We suggest, however, that any attempts to trace the neural mechanisms underlying the functional dissociation between localization and identification, regardless of sensory modality, must envisage the specific contribution of motor processes in the mapping of local sensorimotor space. Spatial relationships in a given sensory field can be processed by different motor instruments, each having its own restricted field of application.[20] Manipulative activities using elaborate finger movements certainly require the somatomotor organization of central cortex. Transport of the hand through oriented arm movements could be differently organized if visually, tactually, or auditorily triggered. The same could be said for the guidance of locomotor activity. We may therefore expect to find increasing evidence of the multichanneling of sensory information to supply the sensory and motor requirements of these functional systems.

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