Responses of Human Somatosensory Cortex to Stimuli below Threshold for Conscious Sensation

B. Libet
W. W. Alberts
E. W. Wright, Jr.
B. Feinstein

B. Libet, Neurophysiology of Consciousness
© Springer Science+Business Media New York 1993
Responses of Human Somatosensory Cortex to Stimuli below Threshold for Conscious Sensation

Abstract. Averaged evoked responses of somatosensory cortex, recorded subdurally, appeared with stimuli (skin, ventral posterolateral nucleus, cortex) which were subthreshold for sensation. Such responses were deficient in late components. Subthreshold stimuli could elicit sensation with suitable repetition. The primary evoked response was not sufficient for sensation. These facts bear on the problems of neurophysiological correlates of conscious and unconscious experience, and of "subliminal perception."

Previous studies have indicated that the first appearance of any evoked potential in sensory cortex, elicited by a stimulus to skin or sensory nerve, coincides with the threshold for some report of subjective sensation by the human subject (1). A similar relationship was reported for the threshold of sensory discrimination in the cat, upon stimulation of a cutaneous nerve (2). Such conclusions were based upon recordings made with electrodes on the scalp or situated epidurally. This provides a relatively diffuse lead from unresponsive as well as responsive cortex (see, for example, 3). It has been demonstrated in monkeys that localized responses recorded with cortical surface electrodes may be essentially indetectable with scalp electrodes (4); we have found this to be true in man (see also 3). In the present work, the recording electrode is placed subdurally, directly on the pia-arachnoid surface of somatosensory cortex (postcentral gyrus). In addition, the stimulus to the skin or to ventral posterolateral (VPL) nucleus of thalamus is so located as to elicit a sensation within the same somatic area as that in which the sensation was subjectively felt when the recording site on somatosensory cortex was stimulated directly. With such relatively precise localization it has become quite evident that at least some components of the evoked potential are recordable in somatosensory cortex with stimulus levels which are distinctly below those required to elicit any conscious sensory experience. This was true whether stimuli were applied to the skin, the specific projection relay nucleus in the thalamus (VPL nucleus), or directly to somatosensory cortex.

Subjects were patients undergoing stereotaxic neurosurgical therapy for motor dyskinesias or intractable pain, who volunteered some study time during the operative stage in which they had to remain unanesthetized for purposes of therapy (5). Local anesthetic was injected into the scalp but generally no premedications were administered. Conditions of such experiments and criteria for conscious sensory experience have been described earlier (6, 7). The subject was alerted to attend to the stimulus and was asked to report (i) whether he subjectively experienced or "felt" a sensation even if it was very weak, (ii) whether he felt none at all, or (iii) if he was uncertain about having felt a sensation. With single-pulse stimuli the range of stimulus intensity of which the subject was uncertain was usually small (less than 5 percent for skin); false positive responses almost never occurred. (Throughout this report, the terms threshold or subthreshold refer exclusively to the ability or inability of stimuli to elicit conscious sensory experience, rather than to their ability to elicit electrophysiological responses. In order to keep this distinction clear to the reader, the term threshold-c will be used to describe threshold stimuli that can elicit conscious experience. We are not implying that a subthreshold stimulus as determined under the present conditions would necessarily remain subthreshold under all conditions of testing, for example, with extensive training of the subject.) All recordings were unipolar (8), with the three skull contacts of the stereotaxic frame generally serving as the reference or indifferent lead (except for d-c recordings). The stimuli were constant-current electrical pulses applied to the skin through a 5-mm disc, or to VPL by means of a coaxial needle electrode. To elicit direct cortical responses, stimuli were applied within 1 mm of the recording site by a twisted pair of metal wires.