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Journal

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES, 388(JUN)

ISSN

0077-8923

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Publication Date

1982

DOI

10.1111/j.1749-6632.1982.tb50838.x

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NATURAL STIMULI EVOKING SOMATOSENSORY POTENTIALS

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The definition of somatosensory evoked potentials has customarily employed percutaneous electrical stimuli to activate mixed nerves, such as the median nerve at the wrist, or sensory nerves, such as the digital nerves at the fingers. The use of a natural stimulus such as touch or pressure to evoke potentials has been utilized infrequently.¹⁻⁷

An advantage of a natural stimulus is that it provides information as to the function of the receptor and its terminal nerve fibers whereas electrical stimulation of nerve trunks bypass these areas. Secondly, both the type of neural elements and the central pathways activated are relatively specific with a natural stimulus compared to electrical stimulation of nerve trunks. A major disadvantage of a natural stimulus is that complex procedures are often required for its quantification. Moreover, since natural stimuli usually activate a restricted number of neural elements, the amplitude of their evoked potentials may be less than those evoked by electrical stimulation.

Over the past few years we have had the opportunity to work on this problem and have utilized two types of natural stimuli: (1) mechanical deformation of the skin of the finger that feels like a tap,⁸⁻¹³ and (2) flexion or extension of the ankle joint to activate muscle spindle receptors in the gastrocnemius or tibialis anterior muscles.¹⁴ These natural stimuli were capable of evoking potentials at several levels of the somatosensory pathway.

Tactile stimuli elicit clear potentials at many levels of the somatosensory pathway but are of low amplitude compared to the potentials evoked by electrical stimulation of nerve trunks (FIGURE 1). Their scalp distributions are comparable¹¹ as are the effects of stimulus rate.¹⁰

Preliminary studies using tactile stimulation were completed in neonates and showed clear potentials at several levels of the pathway.¹² However, cortical potentials could only be detected in 2 of 10 newborn infants compatible with a maturational delay in cortical circuits in youngsters of this age.

Conduction times along the sensory pathway to natural tactile stimuli can be calculated and used to assess abnormalities in clinical populations.¹⁵ For instance, in an unpublished study of diabetic and uremic patients with peripheral neuropathy, we (Starr and Pratt) found the conduction time from mechanical stimulation of the index finger to the occurrence of the evoked potentials recorded over the median nerve to be abnormal in 8 of 11 patients with uremia but normal in the 7 patients with diabetes. However, in both groups of patients proximal afferent conduction times between the wrist and axilla from electrical stimulation of the digital nerves were consistently abnormal (10/11 uremic patients; 6/7 diabetic patients). This finding would suggest

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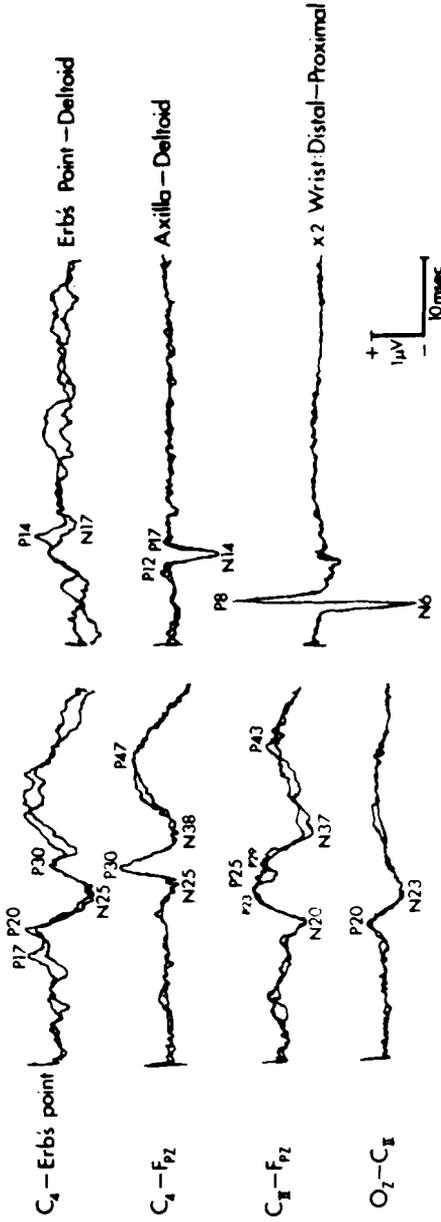


FIGURE 1. Somatosensory potentials evoked by 4.4/sec mechanical tap of the nail of the index finger. 512 stimuli comprise each average and duplicate averages are plotted. Electrodes were placed at several scalp and limb positions to define the potentials along the somatosensory pathway. The components are labeled according to their polarity (P, positive; N, negative) and latency (in msec).

that the terminal parts of the nerve fiber are particularly affected in uremic patients compared to those with diabetes.

We have recently extended the use of natural stimuli to that of muscle stretch to evoke cerebral potentials in humans.¹⁴ We believe that muscle stretch was effective in evoking the potential by activating Ia afferents from muscle spindles (FIGURE 2). The definition of Ia afferent input to the cerebral hemispheres provides a means for the clinician to directly assess muscle spindle-cortical connections in a variety of clinical disorders.

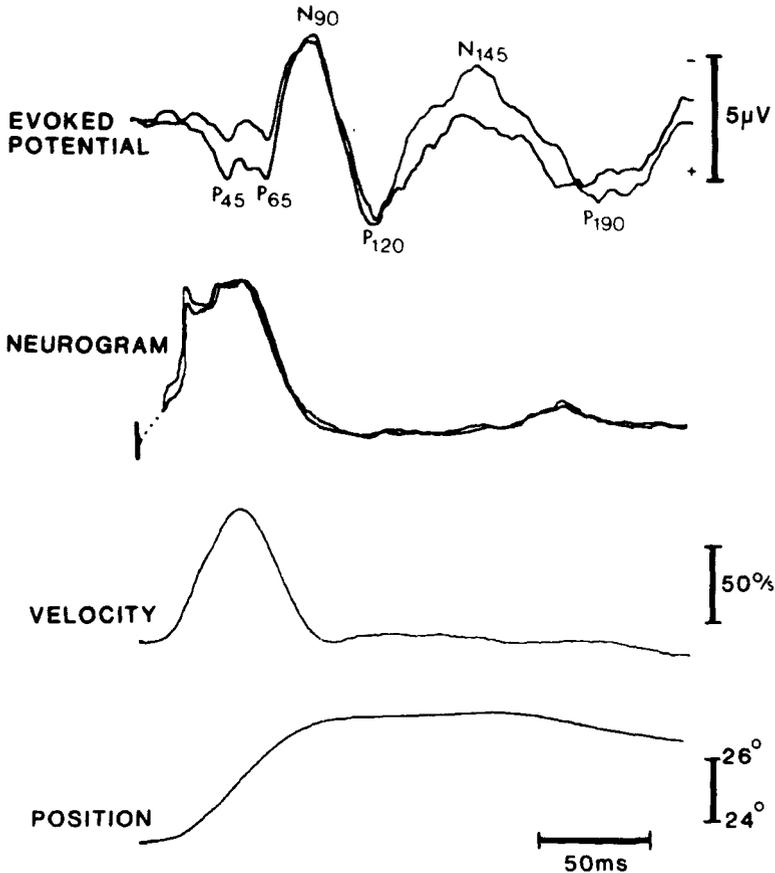


FIGURE 2. Somatosensory potentials evoked by muscle stretch. Two superimposed averages of cerebral evoked potentials (C_z referenced to F_{pz} ; top trace), and of muscle afferent activity (integrator time constant: 0.01 sec), recorded by a microelectrode within a fascicle of the peroneal nerve innervating tibialis anterior (second trace); the velocity profile of the plantar-flexion movement of the ankle (third trace); and ankle joint position (bottom trace). The repetition rate of stretch was 1 Hz. The components of the evoked potential are labeled according to polarity at the vertex electrode (P, positive; N, negative) and approximate latency (in msec) in normal adults. Peak velocity of movement is reached at 46 msec, maximum muscle afferent activity at 37 msec, and the onset of the initial deflection of the evoked potential at 32 msec.

We propose that the use of natural stimuli to study somatosensory functions, both by behavioral and electro-physiological means, is physiologically appropriate and will result in data that can help clarify mechanisms both of normal sensory function and of clinical disorders of sensation. However, there are numerous technical problems that must be solved before such studies can be considered "routine," as are the present studies using electrical stimulation of nerve trunks. Nevertheless, techniques are now available for those wishing to analyze natural physiological approaches to evoked potential correlates of somatosensory function.

REFERENCES

1. SEARS, T. A. 1959. Action potentials evoked in digital nerves by stimulation of mechanoreceptors in the human finger. *J. Physiol.* **148**: 30.
2. BANNISTER, R. G. & T. A. SEARS. 1962. The changes in nerve conduction in acute idiopathic polyneuritis. *J. Neurol. Neurosurg. & Psychiatry* **25**: 312-328.
3. KJELLMAN, A., E. L. LARSSON & T. S. PREVEC. 1967. Potentials evoked by tapping recorded from the human scalp over the cortical somatosensory region. *Electroencephalogr. Clin. Neurophysiol.* **23**: 396.
4. MCLEOD, J. G. 1966. Digital nerve conduction in the carpal tunnel syndrome after mechanical stimulation of the finger. *J. Neurol. Neurosurg. Psychiatry* **29**: 12-22.
5. FRANZEN, O. & K. OFFENLOCH. 1969. Evoked response correlates of psychophysical magnitude estimates for tactile stimulation in man. *Exp. Brain Res.* **8**: 1-18.
6. LARSSON, L. E. & T. S. PREVEC. 1970. Somatosensory response to mechanical stimulation as recorded in human E.E.G. *Electroencephalogr. Clin. Neurophysiol.* **28**: 162-172.
7. NAKANISHI, I., Y. SHIMADA & Y. TOYOKURA. 1974. Somatosensory evoked responses to mechanical stimulation in normal subjects and in patients with neurological disorders. *J. Neurol. Sci.* **21**: 289-298.
8. PRATT, H., R. N. AMLIE & A. STARR. 1979. Short latency mechanically evoked somatosensory potentials in humans. *Electroencephalogr. Clin. Neurophysiol.* **47**: 524-531.
9. PRATT, H., A. STARR, R. N. AMLIE & D. POLITOSKE. 1979. Mechanically and electrically evoked somatosensory potentials in normal humans. *Neurology (Minneapolis)* **29**: 1236-1244.
10. PRATT, H., D. POLITOSKE & A. STARR. 1980. Mechanically and electrically evoked somatosensory potentials in humans: Effects of stimulus presentation rate. *Electroencephalogr. Clin. Neurophysiol.* **49**: 240-249.
11. PRATT, H. & A. STARR. 1981. Mechanically and electrically evoked somatosensory potentials in humans: Scalp and neck distribution of short latency components. *Electroencephalogr. Clin. Neurophysiol.* **51**: 138-147.
12. PRATT, H., R. N. AMLIE & A. STARR. 1981. Short latency mechanically evoked peripheral nerve and somatosensory potentials in newborn infants. *Pediatr. Res.* **15**: 295-298.
13. PRATT, H., R. N. AMLIE & A. STARR. 1979. Somatosensory potentials in humans evoked by both mechanical stimulation of the skin and electrical stimulation of the nerve. *In* *Sensory Functions of the Skin of Humans*. Dan R. Kenshalo, Ed. pp. 109-128. Plenum Press, New York, N.Y.
14. STARR, A., B. MCKEON, N. SKUSE & D. BURKE. 1981. Cerebral evoked potentials to muscle stretch in man. *Brain* **104**: 149-166.
15. VAZIRI, D., H. PRATT, J. K. SAIKI & A. STARR. 1981. Evaluation of somatosensory pathway by short latency evoked potentials in patients with end-stage renal disease maintained on hemodialysis. *Int. J. Artificial Organs* **4**: 17-22.

DISCUSSION OF THE PAPER

T. ALLISON: Do you have data on the scalp topography of P45? One might expect that this component is generated in area 3A since this is where the muscle spindle afferents are thought to terminate.

A. STARR: Yes. This component is largest around the vertex, but our electrodes were not spaced close enough to show whether or not the distribution was asymmetric over the two hemispheres.

R. CRACCO: Some of your colleagues from Australia recently provided evidence that suggests that the latency of the scalp response with mixed nerve stimulation is determined by dynamic spindle input, presumably Group 1A. Would you comment on this?

STARR: Yes, they compared SEPs of the sural nerve at the ankle with that of the posterior tibial nerve at the ankle. The latency of the posterior tibial nerve SEP was shorter than the sural nerve SEP, suggesting that the 1A afferent fiber pathways are conducted faster in the spinal cord than the pure cutaneous ones.