CHAPTER 137

The Kinetic Topography Of The Pectoralis Major Muscle Related To Dynamic Reconstruction Of The Head And Neck

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The past several years have seen a dramatic development in the use of both regionally transposed myocutaneous and distantly transferred free flaps in head and neck reconstruction.[1,2] Initially these flaps served to augment and replace tissue defects lost in ablative procedures, acting purely as static components. As concepts expanded, the free flaps began to express a full spectrum of physiologic function, finding particular effectiveness in the restoration of muscular contraction in the extremities.[6]

It seemed a natural extension of the reconstructive tenets developed for free flaps to use the vastly more secure, regionally transposed pectoralis major myocutaneous flap for dynamic reconstruction of the head and neck region. This muscle flap not only provides excellent tissue augmentation but also is extremely viable because its pedicled vascular supply is not interrupted during the reconstructive procedure. In addition, it has the capacity to assume a dynamic physiologic function.

This study was undertaken to define the neurophysiologic topography of the pectoralis major muscle so that reinnervation and controlled denervation techniques could be consistently employed when using the contractile elements of this flap in dynamic reconstruction of the head and neck.

PECTORALIS MAJOR MUSCLE ANATOMY

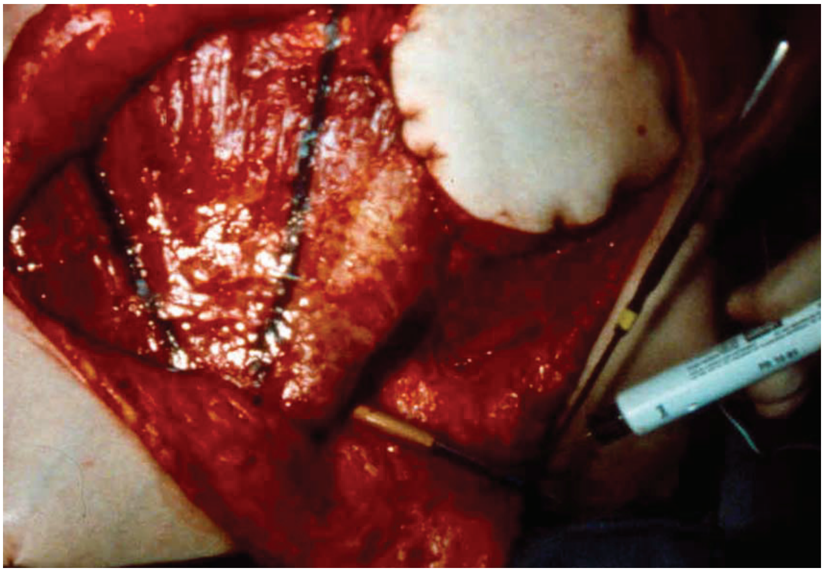
The pectoralis major is a triangular muscle covering the anterosuperior portion of the thorax. It is composed of a clavicular portion arising from the medial half of the clavicle, which blends with the sternocostal component originating from the aponeurosis of the obliquus externus muscle. Both segments insert into the intertubercular sulcus of the humerus such that the sterno-costal fibers lie posteriorly to those originating from the clavicle.

The dominant vascular supply is the pectoral branch of the thoracoacromial artery, which in turn arises from the second division of the axillary artery. Adjunctive supply is from three sources: the lateral thoracic and pectoral branches of the intercostals, which course within the fascial envelope of the muscle's deep surface,[5] and a smaller vessel that migrates from the axillary artery distal to the takeoff of the thoracoacromial artery.

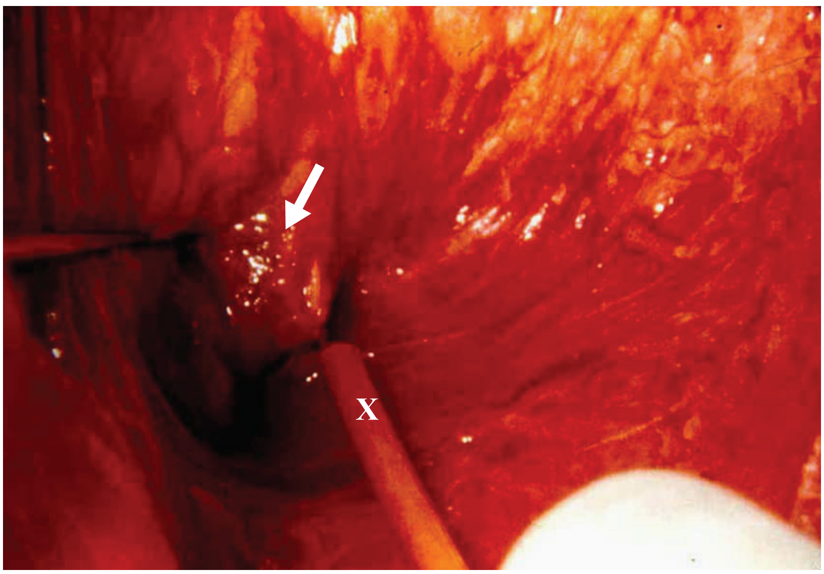
The medial (C8 to T1) and lateral (C5 to C7) pectoral nerves innervate the pectoralis major muscle. The lateral pectoral nerve arises from the lateral cord of the brachial plexus, pierces the clavipectoral fascia, and is distributed on the deep surface of the muscle. The medial pectoral nerve, designated as such from its origin in the medial cord of the brachial plexus and not from is location on the pectoralis muscle, first pierces the pectoralis minor muscle, eventually sending 2 or 3 branches to the major. There exists a direct communicating branch between the lateral and medial pectoral nerves, which forms a loop near their exit from the brachial plexus.[3]

METHOD

This study consisted of 21 selected clinical cases of pectoralis major myocutaneous flap dissections. Each flap was raised in a manner that ensured maximal continuity of the neurovascular supply. This was achieved by leaving the entire pectoralis major muscle intact and only elevating the chest skin form the muscle, except in the donor area. From a lateral approach the pectorlais major muscle was lifted from the chest wall in a plane superficial to the



A.



B.

Fig. 137-1. A, Experimental preparation of pectoralis major myocutaneous flap. Note the insulated nerve hook and stimulator. **B**, View under the pectoralis flap. Arrow shows the vascular associated nerve complex (VANC) with the nerve hook (X) grasping the largest diameter nerve in the VANC.

pectoralis minor muscle by finger dissection, maintaining all origins and insertions of the muscle. At this juncture, identification and subsequent stimulation of various nerve branches to the muscle were performed, and patterns of muscular contraction relating to each nerve were identified. Only after this testing was the flap trimmed and modified to facilitate its intended reconstructive function (Fig. 137-1, *A*).

No attempt was made to meticulously identify every nerve fiber, since this baseline anatomic study has already been admirably recorded by Manktelow et al.[7] Our intent was to identify the clinically significant nerves, their locations, and their related contractile topography. Dissection beneath the fascial plane of the pectoralis and in direct continuity with the major vascular pedicles was necessary to identify the nerves and to potentiate their reponse to direct stimulation. Each was recorded by postoperative mapping and in particular circumstances by photographs. Nerve stimulation was performed at increasing intervals of 0.5, 1.0, and 2.0 milliamps with a new Concept Vari-Stim III Surgical Nerve Locator. A specially designed insulated nerve hook allowed selective stimulation of individual nerves (Fig. 137-1, *B*).

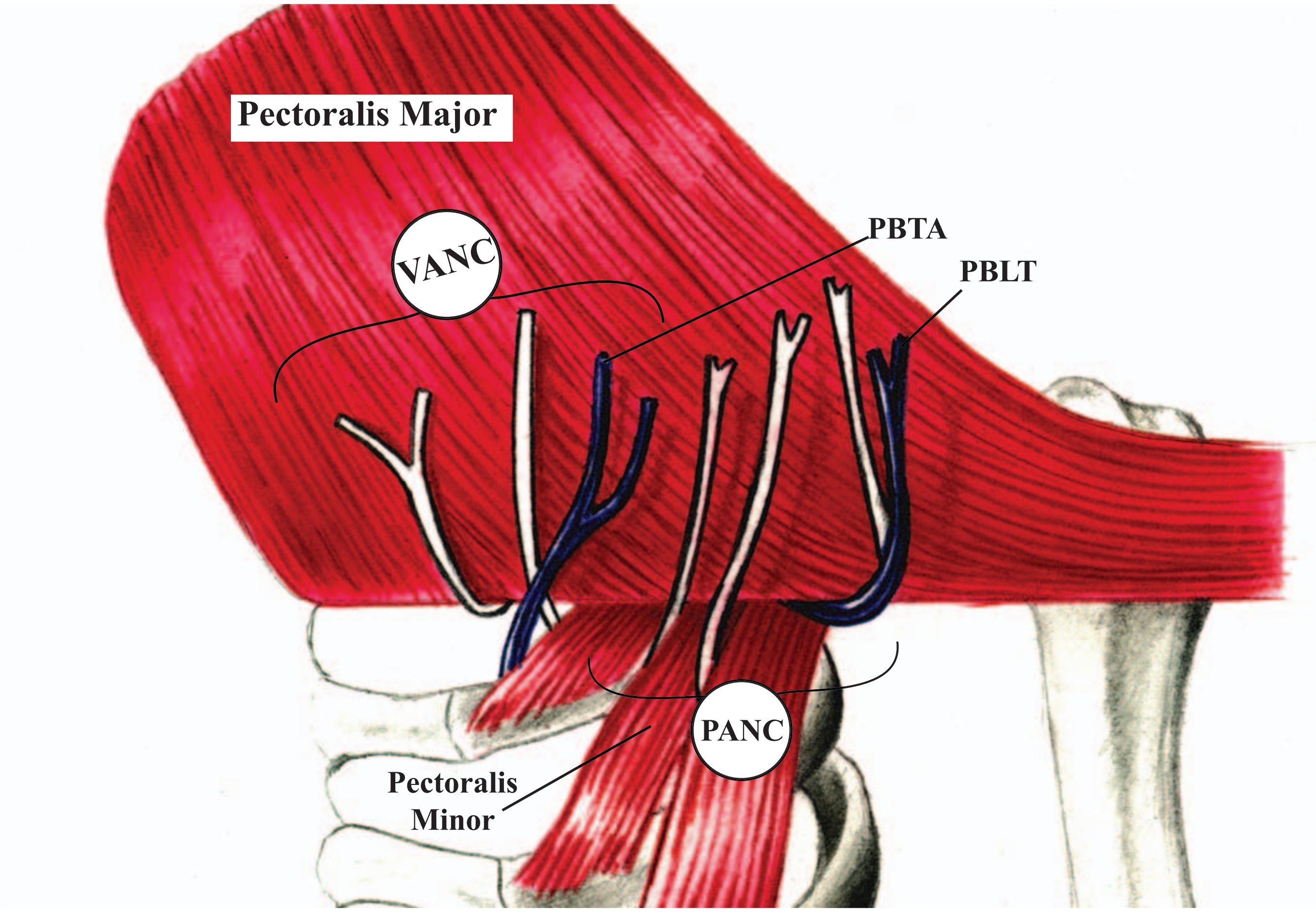


Fig. 137-2. Neurovascular anatomy of pectoralis major muscle. **PBTA**, Pectoral branch of thoracoacromial artery; **PBLT**, pectoral branch of lateral thoracic artery.

RESULTS

Neurovascular anatomy

Two basic neuroanatomic units were consistently identified in all 21 specimens. These consisted of a nerve complex intimately associated with pectoral branch of the thoracoacromical artery, arbitrarily designated as vascular associated nerve complex (VANC), and a second nerve complex that pierced the pectoralis minor muscle before ramifying onto the pectoralis major muscle, designated pectoralis associated nerve complex (PANC) (Fig.137-2).

There were uniformly two major nerves in the VANC and one small branch medial to the artery. The larger never was always more lateral and within the confines of the vascular bundle. The PANC was more variable but always included at least one nerve and as many as three.

Contractile elements

In all 21 specimens the pectoralis major muscle responded to stimulation in four separate regions. (Fig. 137-3). The superior clavicular portion of the muscle (*A*) maintained its anatomic functional integrity. The inferior Sternocostal components always contracted in three separate regions (*B* to *D*). The innervation patterns (kinetic topography) of these regions differed, however, in terms of the nerve responsible for stimulation of each element and the force of contraction.

Kinetic Topography

Two neurotopographic patterns of stimulation and subsequent contraction were described in this study. In 16 of 21 specimens a VANC-dominant pattern emerged, which consisted of area *A* being stimulated by the most medial branch of VANC, areas *B* and *C* by VANC nerves, and area *D* by a PANC nerve. The most forceful contractile element was in area *C* and was stimulated by the largest diameter nerve in the VANC, intimately associated with the vascular muscle (Fig. 137-4).

In 5 of 21 cases a PANC-dominant pattern emerged (Fig. 137-5). The most forceful contractile element in this setting is in area *D*, from the largest diameter nerve in the PANC. Area *A* was stimulated by the most medial branch of VANC, as in the VANC-dominant pattern just described, and areas *B* and *C* were stimulated by nerves from the VANC complex.

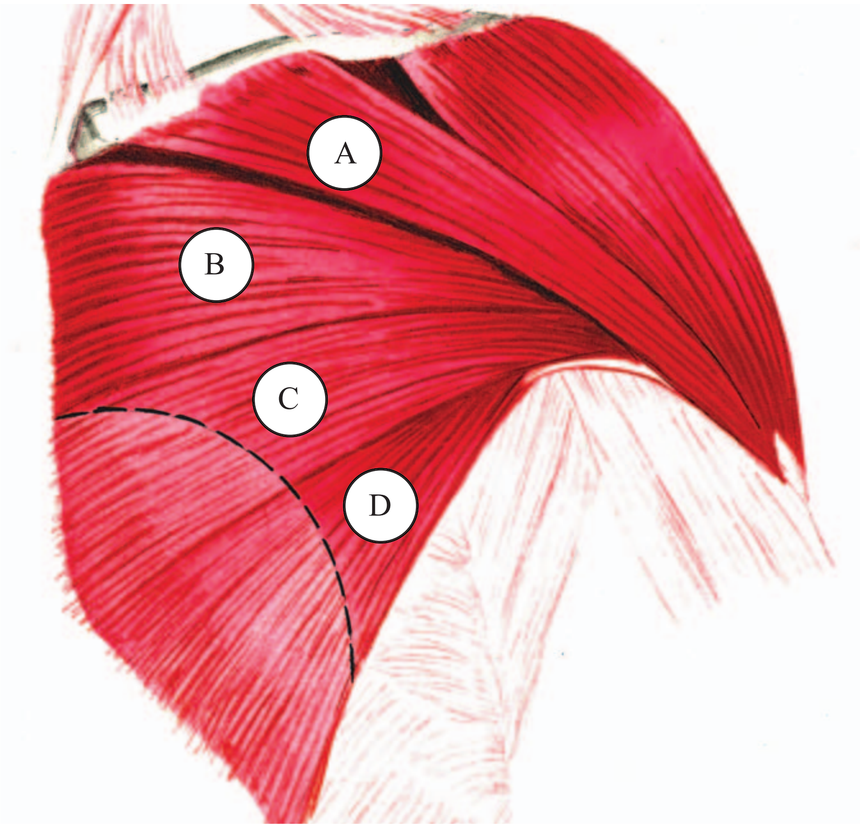


Fig. 137-3. Contractile elements of pectoralis major muscle. **A**, Clavicular component; **B** to **D**, sternocostal components.

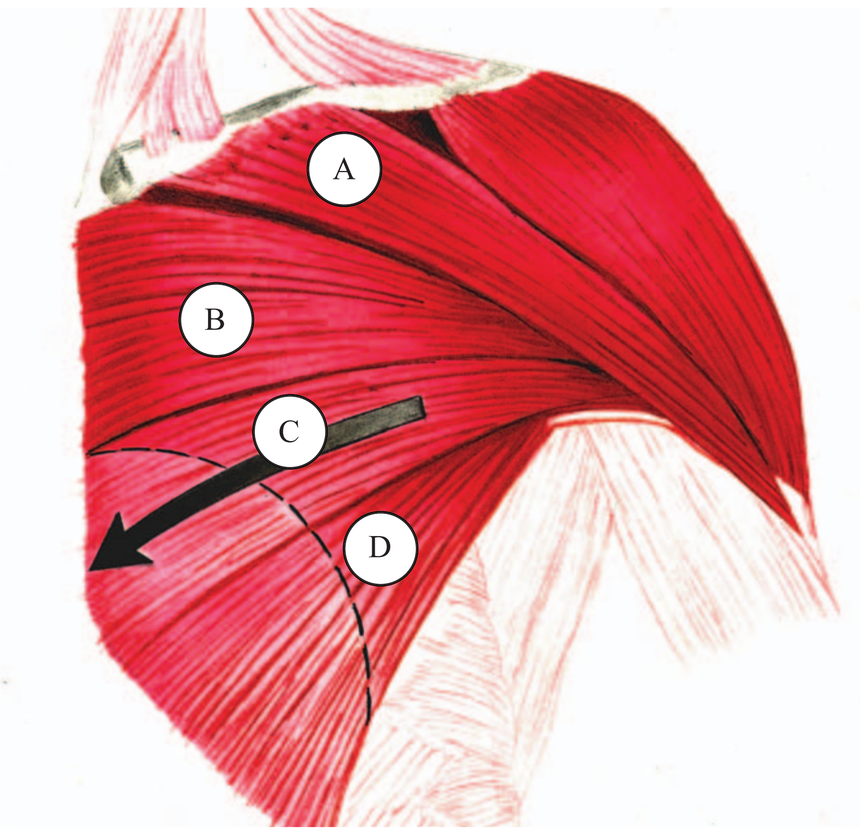


Fig. 137-4. VANC- dominant kinetic topographic pattern. (Light area bounded by dotted lines is potential donor site region.) **A**, Clavicular component; **B** to **D**,

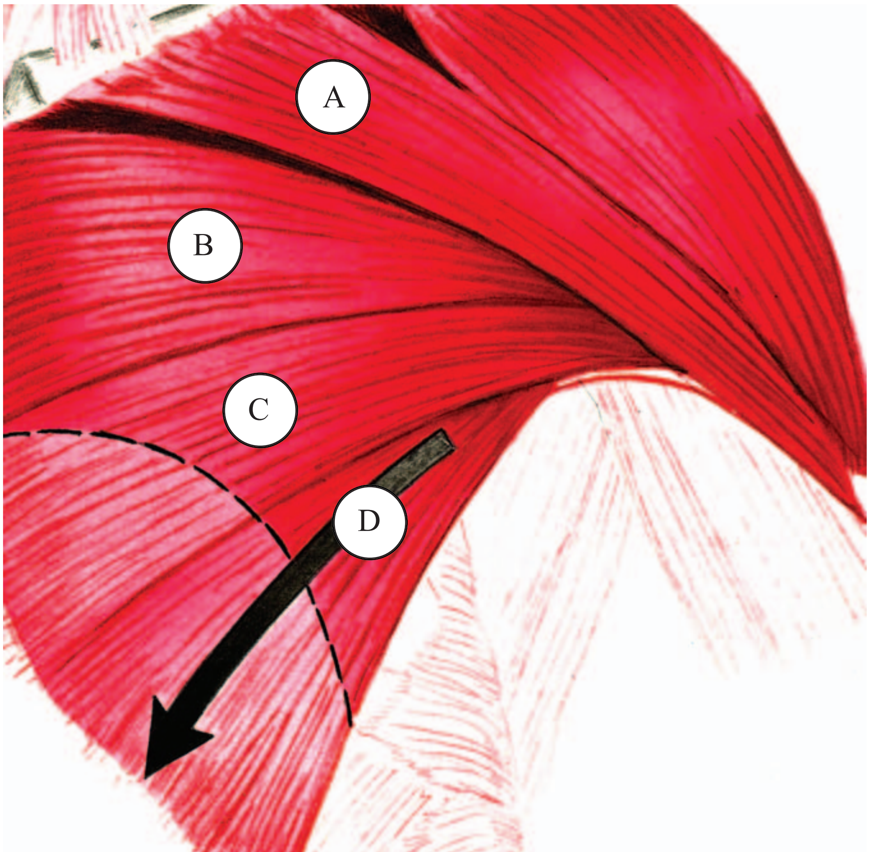


Fig. 137-5. PANC-dominant kinetic topographic pattern. **A**, Clavicular component; **B** to **D**, sternocostal components.

In summary, the largest diameter nerve invariably innervated the most forceful contractile element. If this nerve was from the VANC, the dominant area was *C*, and if the nerve was from the PANC, the dominant area was *D*. These data can be summarized as follows:

1. VANC-dominant pattern
   Area *A*: most medial VANC nerve
   Area *B*: VANC nerve
   Area *C*: VANC nerve (major contractile element)
   Area *D*: PANC nerve
2. PANC-dominant pattern
   Area *A*: most medial VANC nerve
   Area *B*: VANC nerve
   Area *C*: VANC nerve
   Area *D:* PANC nerve (major contractile element)

These results highlight several important factors that demand consideration when contemplating the pectoralis major muscle as a dynamic reconstructive entity. The first basic tenet is to identify the dominant pattern of contraction and its associated nerve supply and to include this major avenue of contraction in the prepared flap. If the particular specimen demonstrated a VANC-dominant pattern of innervation, then it would be safe to fabricate the muscle pedicle more medially by trimming the lateral extent of the muscle. If, however, a PANC-dominant pattern was delineated, then a significant portion of the lateral extent of the pectoralis major muscle must be included in the final specimen to obviate inadvertent disruption of the neurotopographic elements.

The study highlights the dominant nerve in the two patterns, so that consistent reanastomosis can be achieved in dynamic reconstruction. Coincidentally, the study specifies which nerves need to be sacrificed when optimal denervation of the muscle is indicated.

POTENTIALS FOR DYNAMIC RECONSTRUCTION IN THE HEAD AND NECK

The pectoralis major myocutaneous flap is optimally suited for dynamic reconstruction of the head and neck area. It is regionally situated, consistently viable, capable of significant tissue augmentation, amenable to intricate fabrications, and most notably a combination of a forcefully contractile muscular element with a definable segmental innervation.

There are four potential modalities available for creating kinetic activity in a transposed pectoralis major muscle. Primary direct cranial nerve reanastomosis offers optimal physiologic compatibility, whereas crossed cranial nerve anastomosis, muscle-to-muscle onlay myoneurotization techniques, and intentional maintenance of the original pectoral nerve supply serve to reasonably simulate originally intended motion in the reconstructed area.

The major dynamic units in the head and neck amenable to rehabilitation are the tongue (hypoglossal nerve), facial musculature (facial nerve), masticatory system (trigeminal nerve), and, of less importance, secondary deglutitive components of the pharynx and upper esophagus (glossopharyngeal and vagus nerves). In primary direct cranial nerve reanastomosis the proximal segment of the appropriate cranial nerve is connected to the distal neuromuscular segment of the skin muscle flap, as established by electrical nerve stimulation. Direct nerve-to-nerve or nerve-to-muscle reanastomosis can be accomplished. Reconstructions of the tongue using this procedure have been described by Conley, Sachs, and Parke.[4] Additionally, the trigeminal nerve could power a masticatory component if the pectoralis major muscle were so conceived, as could the facial nerve be used to simulate facial movements in large ablative defects of the facial region in selected cases. These concepts are currently under active clinical investigation. Theoretically possible, although of little clinical significance, would be an innervation of the glossopharyngeal nerve into a reconstructed palate or pharyngeal area with the pectoralis major flap.

The second major dynamic rehabilitative technique is the crossed cranial nerve reanastomosis in which the trigeminal nerve could innervate the pectoralis major muscle serving as a facial muscle complex or a new tongue. This technique expands the clinically accepted concept of masseter muscle transposition for regional facial paralysis.

The third principle of dynamic reconstruction is direct myoneuroization of the muscle flap by the residual local muscle tissue component. The potential for success of this method lies in the concept of reinnervation of a well-nourished denervated muscle by a viable muscle with a functional neural supply. Maximal effectiveness of this technique requires an independent blood supply to both muscles and meticulous interdigitation of the muscle into a completely denervated host muscle. The denervation is necessary to ensure optimal receptivity for the budding axons into the transposed pectoralis muscle. With the information presented in this chapter, maximal denervation can be achieved with consistently improved results.

The fourth option is to transfer the pectoralis flap into the wound with its principal nerve supply to the tip donor area intact. The introduction of this muscle segment will produce some motion, albeit controlled by the cervical and thoracic nerve segments. The success of this procedure rests on a postoperative training program that enhances and stimulates subliminal cortical adaptation.

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