Effects of Somatosensory Stimulation on Use-Dependent Plasticity in Chronic Stroke

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**Background and Purpose**—There is a need to develop strategies to enhance the beneficial effects of motor training, including use-dependent plasticity (UDP), in neurorehabilitation. Peripheral nerve stimulation (PNS) modulates motor cortical excitability in healthy humans and could influence training effects in stroke patients.

**Methods**—We compared the ability of PNS applied to the (1) arm, (2) leg, and (3) idle time to influence training effects in the paretic hand in 7 chronic stroke patients. The end point measure was the magnitude of UDP.

**Results**—UDP was more prominent with arm stimulation (increased by 22.8%) than with idle time (by 2.9%) or leg stimulation (by 6.4%).

**Conclusions**—PNS applied to the paretic limb paired with motor training enhances training effects on cortical plasticity in stroke patients. (*Stroke. 2006;37:246-247.*)

**Key Words:** nerve stimulation ■ neuronal plasticity ■ stroke ■ stimulation, transcranial magnetic

Use-dependent plasticity (UDP) is instrumental in motor learning and may play a role in recovery of function after brain lesions. Given the influence of somatosensory input on motor function, it is possible that somatosensory stimulation (SS) potentiates plastic changes associated with use in stroke patients. We evaluated the effects of SS on the ability of stroke patients and healthy subjects to express UDP in the hand. In our UDP protocol, a rapid training period consisting of voluntary thumb movements results in a change in the cortical network representing the thumb that encodes the kinematic details of the training and represents a motor memory influenced by long-term potentiation–like mechanisms. We tested the hypothesis that SS applied to the hand preceding motor training would enhance training effects on UDP in stroke patients and healthy subjects.

**Methods**

Seven patients (4 men; 66.7±4.3 years of age) with single ischemic stroke >6 months before testing were enrolled. Medical Research Council scores (hand muscles) at ictus were <2, but patients recovered to the point of being able to perform isolated thumb movements. Six healthy subjects (4 men; 32±3.5 years of age) were enrolled as additional control. All gave informed consent, and the protocol was approved by the institutional review board.

Patients participated in 3 different sessions randomly ordered in a crossover design and separated by ≥24 hours (a safe period to avoid carryover effects). UDP was tested after 2-hour stimulation of (1) ulnar, median, and radial nerves in the paretic hand (arm stimulation); (2) tibial, superficial peroneal, and sural nerves in the paretic leg (leg stimulation; only stroke subjects); and (3) no stimulation (idle time; Figure and also see supplemental Figure I, available online at http://stroke.ahajournals.org). Trains of electrical stimulation consisting of 5 pulses at 10 Hz (1-ms duration each) were delivered every second using a stimulator (Grass; Astro-Med, Inc) at an intensity adjusted to elicit compound muscle action potentials up to 100 μV. For electromyographic recordings, disposable electrodes were placed over the belly of abductor pollicis brevis, abductor digitii minimi, and extensor digitorum communis muscles in the upper extremity (arm stimulation) and tibialis anterior muscle and abductor hallucis muscle in the lower extremity (leg stimulation).

We determined the maximal thumb movement rate that each patient could sustain over 30 minutes. UDP was tested after thumb movements cued by an auditory signal in a direction opposite to the baseline transcranial magnetic stimulation (TMS)–evoked movement direction for 30 minutes at each subject’s maximal rate. Healthy subjects had a constant rate of 1 Hz. On each day, subjects received 1 of the 3 interventions (arm, leg-only patients, and idle time; see online supplement, available at http://stroke.ahajournals.org). Motor training was the same in all sessions. To describe intervention effects on UDP, we defined a training target zone (TTZ) as a window of ±20° centered on the training direction. Our end point measure of UDP was the increase in the proportion of TMS-evoked movements that fell within the TTZ.

**Statistical Analysis**

Data were analyzed blindly off-line. Increase in the proportion of TMS-evoked movements in the TTZ was analyzed with a 1-way repeated-measures ANOVA with factor stimulation (3 levels in patients; 2 levels in healthy subjects). Movement threshold, amplitude of motor-evoked potential (MEP), and training kinematics were analyzed using factorial ANOVA with factor stimulation. Fisher post hoc tests were performed. Data are expressed as mean±SE and considered significant if P<0.05.
results demonstrated that this intervention may enhance the beneficial effects of a single motor training session on UDP in stroke patients. Combination of SS with training protocols could conceivably be applied in the future to improve the effects of customary rehabilitative interventions.

Acknowledgments
This work was partially supported by a grant from Office of Alternative Medicine-NIH and from the intramural program at NINDS/NHI. We thank our subjects for their participation in the study. We also gratefully acknowledge N. Dang for invaluable technical support.

References
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Stroke. 2006;37:246-247; originally published online December 1, 2005;
doi: 10.1161/01.STR.0000195130.16843.ac
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://stroke.ahajournals.org/content/37/1/246

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