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# New Directions in Occupational Therapy: Implementation of the Task-Oriented Approach in Conjunction with Cortical Stimulation After Stroke

Lori Bravi and Mary Ellen Stoykov

Chronic upper extremity hemiparesis following stroke is a significant impairment that can limit a person's independence in all aspects of ADL, IADL, and functional mobility. Although recovery of functional independence may be more efficient using traditional compensatory techniques, these therapeutic methods often do not encourage integration of the hemiparetic arm and hand. In contrast, the task-oriented approach to motor recovery of poststroke hemiparesis emphasizes integration of the impaired limb into all functional tasks via skill-based training. Cortical changes have been documented following skill-based training of the upper limb in the healthy animal model. Additionally, the combination of subthreshold cortical stimulation combined with skill-based forelimb training in the induced-stroke rat model has demonstrated better outcomes than training alone. Preliminary research with human stroke survivors using task-oriented training and subthreshold cortical stimulation has shown promising results. The purpose of this article is to introduce an upper limb training protocol that was used in a national multisite trial that compares cortical stimulation in conjunction with task-oriented training to training alone. **Key words:** *cortical stimulation, occupational therapy, stroke, task-oriented training, upper extremity hemiparesis*

Motor recovery of a hemiparetic upper extremity following stroke is frequently a focus of occupational therapy throughout the rehabilitation process. Traditionally, occupational therapists have used the rehabilitation approach, which includes education and adaptation<sup>1</sup> as well as exercise and neurodevelopmental techniques for the involved extremity. For individuals with adequate cognitive and perceptual skills, treatment was primarily directed toward an increased level of independence in functional activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Sessions may have included bathing, dressing, and meal preparation activities, with various compensatory strategies introduced in an effort to efficiently maximize independence as early as possible. As a result, chronic stroke survivors often learn to adopt compensatory strategies involving the use of their unimpaired limb rather than using their impaired limb. Moreover, upper limb movement training requires

significant practice, which is difficult in today's health care environment.

In contrast to this traditional compensatory approach, the contemporary task-oriented approach requires the immersion of the impaired limb into all aspects of ADLs and IADLs rather than allowing compensation with the unimpaired limb. The task-oriented approach<sup>2,3</sup> examines the motor control and motor learning literature and attempts to

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apply scientific findings to practical treatment. This treatment approach assumes that movement results as an interaction of many systems. An individual's movement abilities and the environment interact when he or she is performing a task.

In general, stroke survivors want to regain use of their affected arm even at the chronic stage. Although it was once believed that the poststroke neural recovery phase was limited to 6 months, research has demonstrated that neuroplasticity can be enhanced even in the chronic stroke population.<sup>4</sup> New advances in science and medicine in conjunction with occupational therapy and physical therapy may improve upper extremity motor control outcomes. In this article, we describe a therapy protocol used in a multidisciplinary research study that investigated the concurrent use of upper limb rehabilitation therapy and targeted neurostimulation. For a detailed description of the study in its entirety, the reader is advised to consult the references.

Animal research has emphasized the neuroplastic capabilities of the primary motor cortex. Cortical microstimulation techniques have been used on the motor cortex of healthy rats to determine changes in posttraining cortical topology.<sup>5</sup> Other research using animals with induced-stroke indicates that cortical electrical stimulation may enhance training-induced neuroplasticity by increasing the transmission density of functional neural connections in the affected motor cortex.<sup>6-8</sup> In these studies, reaching and eating tasks involving wells of varying diameters were used to train and refine prehension skills for rats and primates. Although feeding is used as the primary functional activity to encourage upper limb motor recovery in rats, an even greater set of functional skills is needed to train humans during occupational therapy and physical therapy to promote poststroke motor recovery.

In human subjects, stroke researchers use noninvasive techniques such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and transcranial magnetic stimulation (TMS) to track spontaneous recovery from stroke as well as cortical response to motor training.<sup>9</sup> Thus, scientists can obtain precise informa-

tion about poststroke spontaneous recovery and neural changes after training.

Cortical stimulation is a neuromodulation technology being developed by Northstar Neuroscience based in Seattle, Washington. The technology has been studied extensively in preclinical animal trials<sup>6-8,10</sup> where it has been shown to expedite and enhance motor return. An investigational device is being examined in clinical studies to determine if it can expedite and enhance motor return in human stroke patients.<sup>4</sup> If these studies are successful, cortical stimulation could become a regular adjunct to rehabilitation therapy.

Prior to surgical implantation of the device, fMRI was used to locate the specific region of a person's motor cortex responsible for control of the affected distal limb. Once the specific region was located, a craniotomy was performed to position an electrode on the dura over the area of the motor cortex representing the distal limb. Cortical stimulation was delivered through the electrode, which was connected to an investigational pulse generator implanted under the skin just below the clavicle, at a level below the intensity that would cause movement. Electrical stimulation was delivered only while the patients received daily rehabilitation therapy services (approximately 150 minutes per day). At the end of each therapy session, the stimulator was turned off.

Participants recruited for the study were required to meet the following inclusion criteria at enrollment: (a) at least 21 years of age with a history of ischemic infarct above the level of the midbrain, which is identified on computerized tomography (CT) or MRI; (b) stroke occurrence at least 4 months prior to enrollment in the study; (c) moderate upper extremity impairment; (d) a minimum of five degrees of active wrist extension on the affected upper extremity; and (e) neurologically and medically stable. Candidates were excluded from the study if they had one or more of the following: (a) a history of seizures or use of anticonvulsants, (b) hemorrhagic stroke, (c) severe neglect, (d) severe sensory loss of the affected upper extremity, (e) untreated poststroke depression, (f) severe hemiparesis, and (g) introduction of drugs possibly affecting central nervous system up

to 2 months prior to enrollment. Prior history of participation in a rehabilitation program was not considered. These criteria were the same for both the control and investigational groups participating in this study.

Once participants were identified for the study and consent was obtained, participants were assigned to control or investigational groups via a computerized randomization program. A battery of baseline assessments was administered to each participant regardless of randomization. The assessments, chosen for their strong psychometric properties, included the Arm Motor Fugl-Meyer Assessment,<sup>11</sup> Box and Block Test,<sup>12</sup> and the Arm Motor Ability Test (AMAT).<sup>13</sup> The Canadian Occupational Performance Measure (COPM) was used to guide ADL and IADL treatment.<sup>14</sup> These assessments were repeated at various intervals throughout the study including the 6-month follow-up period. Once a baseline level of upper extremity function was established, both the control and investigational groups began a 6-week therapy regimen.

Each day of therapy consisted of a 60- to 75-minute session, a break to allow participants to rest, then a second 60- to 75-minute session, for a total of 120–150 minutes of therapy per day. The first session addressed prefunctional activities and functional activities, whereas the second session addressed a combination of ADLs and IADLs. Ten to 30 minutes of the first session were dedicated to the prefunctional activities, which included proximal exercises and shoulder–elbow coupling. The remaining 45–65 minutes of the first session were dedicated to functional activities, which involved manual skills including grasp, release, and fine motor activities. The division of time within the allotted range for prefunctional and functional activities was left to the therapists' discretion based on participant needs. For example, if a therapist believed that a participant had good scapular and shoulder mobility, the decision could be made to spend 10 minutes on the prefunctional activities in an effort to have 65 minutes of intensive training for the functional activities.

At the beginning of each therapy session, the stimulator was activated for the investigational group. Once the stimulator was activated, the

therapy protocol was followed, which was identical for both the control and investigational groups. This rehabilitation protocol was divided into various components of upper extremity motor control to promote systematic and comprehensive skill training.

The prefunctional activities included exercises to improve scapular control and mobilization, rotator cuff strengthening, and shoulder–elbow coupling. The purpose of these exercises was to facilitate proper alignment, stability, and movement of the arm during reaching. Examples of prefunctional activities included, but were not limited to, proprioceptive neuromuscular facilitation (PNF) scapular and arm patterns, strengthening exercises for the rotator cuff, place and hold isometric exercises, and reaching and pointing to various targets in different areas of the work space. The intention of the prefunctional section was to promote the development of proximal control, which is inherent for hand placement during ADLs and IADLs.

The first session continued with functional activities, which were initially performed on a table or other supporting surface to minimize the demands of multijoint movements. These activities were designed to address grasp, manipulation, and release and were graded according to each person's abilities. Although proximal stability and mobility are prerequisites to controlled reaching, they are not inherent for prehensile tasks. It is well documented that reach and grasp may have separate neural pathways.<sup>15</sup> Thus, the protocol encouraged proximal and distal training, which initially were independent of each other. Training for the functional activities included distal exercises, grasp/pinch, release, reach to grasp, and fine motor activities. The latter included in-hand manipulation. Because the focus of each session was to improve the person's arm function, each activity resembled tasks and task components routinely performed throughout a person's daily routine.

Training for grasping and holding objects can be addressed using a variety of simple, goal-directed activities. For individuals who have limited grasp, holding a jar while opening it with the unaffected hand can facilitate finger flexion in the affected hand. An activity in the protocol for more advanced

prehension training was moving cotton balls from a bag or jar to train for pincer grasp. A paint roller was also used to train for a controlled reach and grasp sequence while the patient rolled it on a table. Once a person gained enough control in the horizontal plane, the activity was graded by rolling the paint roller in the vertical plane on a wall. The extensive training of reaching, grasping, and manipulation was intended to develop strategies to perform ADLs and IADLs with greater efficiency.

At the conclusion of the first 60- to 75-minute session that addressed the prefunctional and functional activities, the participant received approximately an hour break. The stimulator was deactivated for the investigational group at this time. Immediately following this break, the stimulator was reactivated for the investigational group and remained activated during the second 60- to 75-minute session. The focus of the second session was shifted to ADL and IADL performance, which is guided by the items reported by participants during the baseline COPM. Activities included, but were not limited to, dressing tasks, homemaking tasks, telephone or clerical tasks, writing, money management, and computer use. Throughout this portion of the session, the involved upper extremity was used as a gross stabilizer, functional assist, or dominant functional extremity depending on the subjects' abilities, complexity of the task, and prestroke dominance.

In this protocol, the therapist must be able to analyze each person's upper extremity movement and its impact on ADL and IADL performance. Tasks are graded so that the patients can approximate efficient movement patterns. It is essential for the therapist to provide the patient with tasks that are challenging but that also enable optimal movement strategies.<sup>16</sup> The therapist and the patient solve the various movement problems together using any or all of the following: (a) task modification, (b) impairment remediation, (c) strategy training, and (d) environmental adaptation. Task modification may be accomplished by changing the position of the person or task objects. For example, standing may decrease anti-gravity requirements of the arms in some tasks. Surfaces that provide support to the affected limb may also be used to minimize degrees of freedom. For ex-

ample, the arm can be supported on a table during forward reach. Optimizing distal motor strategies, such as conforming the hand to the object, can be accomplished by specific cueing and practice with objects of varying sizes, shapes, and weights. Upper extremity reaching can be improved by remediation of the impairment.<sup>17</sup> For example, proper scapular stability and alignment may improve the range of a person's available reach. A properly aligned scapula will afford a person greater shoulder flexion compared to a scapula that is tipped anteriorly or slightly abducted. Finally, modification of the environment such as using built-up silverware handles may facilitate grasp so that an individual with limited in-hand manipulation can feed him/herself with more independence and efficiency.<sup>18</sup>

### Case Study

A 31-year-old man recently participated in this study. His stroke occurred unexpectedly 7 years prior to the time of enrollment, which left him with residual hemiparesis of his right upper extremity. At the time of his stroke, this young man was right-hand dominant. The significant hemiparesis that he presented with required him to relearn many tasks with his left upper extremity to maintain some level of independence. During acute care and rehabilitation, therapy emphasized compensation rather than functional use of his right arm. He learned how to compensate by tying shoes with one hand, writing with the left hand instead of the right, and brushing his teeth with his left hand. Functional use of the right arm and hand was discouraged because tasks would become more time consuming.

At baseline testing for the study, this patient presented with no functional use of the right upper extremity; however, he did demonstrate good proximal control of the shoulder and elbow. He had very minimal wrist and finger extension and was also limited by significant flexor tone in his forearm, wrist, and fingers. This participant was randomized to the investigational group, which did allow him to potentially benefit from the additional stimulation to the affected motor cortex during his daily therapy regimen. The participant's

therapy focused on improving movement in the scapula, elbow, forearm, wrist, and fingers using functional activities and exercise. For example, activities used to promote supination and wrist extension included using a cell phone, shaving with an electric razor, and combing his hair.

Prior to receiving therapy in the study, this patient reported not using the right upper extremity in 7 years. At the conclusion of his participation in the therapy protocol, he had considerably improved movement in forearm supination, wrist extension, and finger extension. Also, he was able to hold a cup, type bilaterally, dial a phone number, bring a cell phone to his ear, carve a pumpkin, prepare a meal, and zipper a jacket using his right upper extremity as either a functional assist or dominant extremity.

It is important to note that although he did regain a significant amount of function in his right upper extremity, it required significant daily practice. Each participant had to be willing to complete 2.5 hours of therapy 5 consecutive days a week for 6 weeks. Outside of therapy, the participants were expected to use the affected arm and hand as often as possible and adopt the task-oriented approach

on a long-term basis. At the 12-week follow-up, this young man continued to demonstrate improvements as noted in standardized functional assessments, including increases in the Arm Motor Fugl-Meyer score and AMAT.

While the data analyses from this study are still in progress, the results of two smaller nonblinded feasibility studies have been reported elsewhere<sup>4,18-24</sup> and indicate a significant difference in upper extremity motor performance in favor of the investigational group.

This article briefly described a therapy protocol used in a multisite research study investigating the efficacy of cortical stimulation. The research, which was done at the Rehabilitation Institute of Chicago as well as other sites throughout the United States, is currently in the pivotal clinical trial stage. Progress in medical and biomedical research is occurring at an unprecedented rate and may change the course of rehabilitation. It is critical that occupational therapists and physical therapists keep abreast of current neuroscientific research to effectively collaborate with scientists and engineers to design treatment that is evidence based.

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