# A novel neurocognitive rehabilitation tool in the recovery of hemiplegic hand grip after stroke: a case report

**Teresa Paolucci, MD, PhD[a]**
**Serena V. Capobianco, MD[a]**
**Sergio M. Vinciguerra, PT[b]**
**Marta Cilli, OT[b]**
**Ciro Villani, MD[c]**
**Vincenzo M. Saraceni, MD[a]**

[a] Complex Unit of Physical Medicine and Rehabilitation, Policlinico Umberto I Hospital "Sapienza" University of Rome, Italy
[b] "Sapienza" University of Rome, School of Physiotherapy, S. Filippo Neri Hospital, Rome, Italy
[c] University Department of Anatomic, Histologic, Forensic and Locomotor Apparatus Sciences - Section of Locomotor Apparatus Sciences, Policlinico Umberto I Hospital, "Sapienza" University of Rome, Italy

Correspondence to: Teresa Paolucci
E-mail: teresapaolucci@hotmail.com

**Summary**

**Stroke has significant physical, psychological and social consequences. Recent rehabilitation approaches suggest that cognitive exercises with dual-task (sensory-motor) exercises positively influence the recovery and function of the hemiplegic hand grip. The purpose of this study was to describe a rehabilitation protocol involving the use of a new neurocognitive tool called "UOVO" for hand grip recovery after stroke. A 58-year-old right-handed male patient in the chronic stage of stroke, presenting with left-sided hemiparesis and marked motor deficits at the level of the left hand and forearm, was treated with the UOVO, a new rehabilitation instrument based on the neurocognitive rehabilitation theory of Perfetti.**
**The patient was evaluated at T0 (before treatment), T1 (after treatment) and T2 (2 months of follow-up). At T2, the patient showed improvements of motor functions, shoulder, elbow and wrist spasticity, motility and performance. This case report explores the possibility of improving traditional rehabilitation through a neurocognitive approach with a dual-task paradigm (including motor and somato-sensory stimulation), specifically one involving the use of an original rehabilitation aid named UOVO, which lends itself very well to exercises proposed through the use of motor imagery.**
**The results were encouraging and showed improvements in hemiplegic hand grip function and recovery. However, further studies, in the form of randomized controlled trials, will be needed to further explore and confirm our results.**

*KEY WORDS: exercise, motor imagery, neurocognitive, Perfetti method, rehabilitation, stroke.*

## Introduction

Despite the advances in prevention and early care (Barker-Collo and Feigin, 2006), stroke has significant physical, psychological and social consequences.
Recent findings on the rehabilitation of stroke patients suggest that cognitive activities, such as attention, memory and action observation, positively influence the plasticity of the nervous system in favor of motor learning (Sterr and Conforto, 2012): the experiences and information that are generated by these cognitive activities affect the rehabilitation process and improve the functional recovery of the paretic hemibody (Perfetti, 1999).
In particular, somatosensory stimulation, by maintaining cortical representation of the hand and priming the motor system for movement, has a positive impact on the recovery of hand motor function (Grant et al., 2017).
Neurocognitive therapeutic exercise, based on the neurocognitive rehabilitation theory of Perfetti (1999), is an approach that allows the physiotherapist to focus on qualitative and quantitative recovery of hand function, encouraging adequate activation of the patterns that existed prior to the injury by reconstructing the characteristics of hand grip adaptability and variability (Sallés et al., 2017).
It is based on a new strategy for re-learning hand movement, in which kinesthetic and tactile input is exploited instead of visual channels, after which exercises are proposed according to a dual-task paradigm that includes motor and somatosensory stimuli. However, because of the complexity of these exercises, this rehabilitation program requires integrity of higher cognitive functions (memory, attention, perception, motor imagery, problem solving) (Cappellino et al., 2012).
Motor imagery is an important component of neurocognitive exercises: Decety (1996) defined it as a dynamic state during which a person simulates a given action in order better to perceive it.
The purpose of this case report is to describe a protocol based on neurocognitive therapeutic exercises and determine its feasibility and value in the recovery of hand grip after stroke using a new neurocognitive tool, named UOVO.

## Materials and methods

We examined a 58-year-old right-handed male who was diagnosed with left-sided hemiparesis in 2016, and presented with upper extremity predominance due to hemorrhagic stroke in the right mesencephalic site and in the posterior limb of the internal capsule. In September 2016, three months after the acute event and after a period of indoor rehabilitation, the patient had a Mini-Mental State Examination (Folstein et al., 1975) score of 28, a Barthel Index (Mahoney and Barthel, 1965) score of 78, and a visual analog scale (VAS) score of 6/10 for upper limb pain (Huskisson, 1974).

The patient's clinical conditions were stable; he could walk with the aid of a walking stick and performed postural passages autonomously and safely, but he presented a functional deficit of the left hand, which prompted his admittance to our outpatient rehabilitation unit. The neurological examination revealed a marked motor deficit of the left hand and forearm and a mild deficit of the left leg. The clinical findings are reported in Table I.

Mild spasticity was detected, based on the Modified Ashworth Scale (MAS) (Bohannon and Smith, 1987). With his impaired hand (Kapandji, 2006), the patient was only able to perform the palmar hand grip; he had difficulty with the cylindrical grip and could not perform digital grips. A panel of scales was applied at the beginning of the treatment (T0), 4 weeks after the treatment (T1), and at the end of the treatment (at 2 months of follow-up, T2) to evaluate the functional capacity of his left upper limb and left hand. We administered the Motricity Index (MI) (Demeurisse et al., 1980), focusing on pinch grip, flexion of the elbow, and shoulder abduction of the left upper limb; the Fugl-Meyer Assessment Scale (FMAS) (Fugl-Meyer et al., 1975) to evaluate motility of the left upper limb; and the Disabilities of the Arm, Shoulder and Hand Scale (DASH) (Hudak et al., 1996) to measure disability of the hemiplegic upper limb.

The patient entered an outpatient rehabilitation program (RP) (4 days/week, 60-90 minutes per session) to improve his left hand function (i.e. the ability to grasp and manipulate objects), reduce spasticity, and increase muscle strength.

The RP comprised 36 sessions of neuromotor treatments targeting the hemiplegic side [including ambulation training to improve dynamic balance and control of the left foot during locomotion, proprioceptive postural exercises and neurocognitive exercises for the upper limb (UL) and left hand] and 10 sessions of occupational therapy.

Treatments for the UL and left hand consisted of passive mobilization of the fingers, wrist and elbow flexors to improve joint range of motion and thus increase the patient's ability to reach and grasp. Concurrent with this traditional rehabilitation approach, the patient used a new rehabilitation device, called UOVO, according to a neurocognitive rehabilitation protocol. The name UOVO is not an acronym; it is the Italian word for egg and was chosen because of the oval (egg-like) shape of this aid. The UOVO is made of wooden modules of varying circumferences, ranging from the largest in the middle to the smallest at the ends; these can be blocked so as to rotate as one, all in the same direction in relation to the axis, or singly (Fig. 1): when moved singly, they can be turned in different directions. The exercises performed

Figure 1 - A novel rehabilitation tool for hand grip recovery: the UOVO.

using the UOVO, which aimed to improve the patient's left hand grip and, in particular, digital grip, were performed initially with the eyes closed (first level exercise) and then with the eyes open (second level), so as to allow the patient to make maximum use of motor imagery, as illustrated in Figure 2.

Each neurocognitive exercise required the subject to perform a motor task involving proprioceptive or exteroceptive recognition, as shown, for example, in Figures 3 and 4.

In summary, the rehabilitation program with the UOVO was structured as follows:

- Weeks 1-4 of treatment: the patient is seated in a symmetrical position with his feet placed on the floor and hips, knees and ankles flexed at 90°. Exercise no. 1 (placing the two hands on the UOVO): Position: forearms and hands are pronated. The patient places both hands on the UOVO, holding the arms slightly abducted and elbows flexed. Required task: to increase wrist extension by rolling the UOVO and compare the movement of the impaired side with that of the healthy side, also referring to the pre-lesion mental image. The exercise was performed sequentially at the first and then the second level. Exercise no. 2 (rotation): Position: the forearm on the hemiplegic side is pronated or partially supine on the UOVO with a carpometacarpal grip. Required task: to rotate the UOVO, obtaining wrist depression with maintenance of a stable grip and control of spasticity. This exercise was performed sequentially at the first and then the second level. Exercise no. 3 (exercise with sponges): see Figure 3.
- Weeks 5-8 of treatment: the patient is seated in a symmetrical position, with the feet placed on the floor; hips, knees and ankles flexed at 90°; and upper impaired forearm pronated or partially supine on the UOVO with a carpometacarpal grip. Exercise no. 4 (movement of fingers): Required task: to perform a flexion-extension movement of each of the fingers. The patient first had to imagine moving a single finger and then perform the movement. The exercise was performed sequentially at the first and then the second level. Exercise no. 5 (opposition of the thumb). Required task: to place the thumb on the apex of the UOVO and perform an initial opposition movement with the thumb, also referring to the pre-lesion mental image. The exercise was performed sequentially at the second level (eyes open and,

if necessary, with minimal help from the physiotherapist) and then the third level (eyes open, without the help of the physiotherapist). Exercise no. 6 (discrimination of objects with the thumb): Required task: to place the thumb on the apex of the UOVO and perform an initial opposition movement to recognize and differentiate various elements that had been placed on its surface.
The exercise was performed sequentially at the second and then the third level.

- Week 9 until the end of the treatment: the patient is seated in a symmetrical position, with his feet placed on the floor; hips, knees and ankles flexed at 90°; and upper impaired forearm pronated or partially supine on the UOVO with a carpometacarpal grip. Exercise no. 7: Required task: this exercise was performed using different, interchangeable modules of the UOVO, which have different surfaces. Through movement of individual fingers, the patient was required to recognize the various surfaces. The exercise was performed sequentially at the first and then the second level. Exercise no. 8 (also an exercise with different surfaces): Required task: this exercise was performed with different elastic bands placed round the UOVO that had different textures (smooth, soft, rough). The patient, also referring to past experience, had to recognize and differentiate the various surfaces. The exercise was performed sequentially at the first, second and third levels. Exercise no. 9 (exercise with different elements): Required task: to recognize, through movement of the fingers, elements of various sizes that were placed on the UOVO (i.e. inserted into an elastic band that was wrapped around the aid).
The exercise was performed sequentially at the first, second and third levels (Fig. 4).

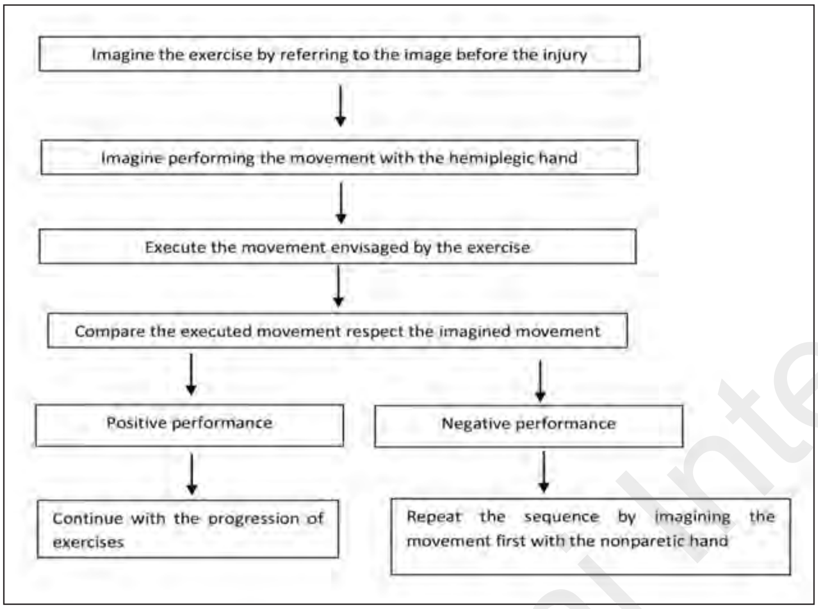


Figure 2 - Motor imagery progression exercise.

Figure 3 - Exercise with sponges. The patient is seated in a symmetrical position, with the feet placed on the floor; hips, knees and ankles flexed at 90°; and forearm and hand of the impaired limb pronated. The task is to identify precisely, through touch, sponges of different consistencies and sizes. In this case, the information is pressure-type. Resolving a pressure-type task is more complex, because it requires active contraction by the patient, even though it is facilitated by the UOVO. This exercise is performed at the first and then the second level (see text).

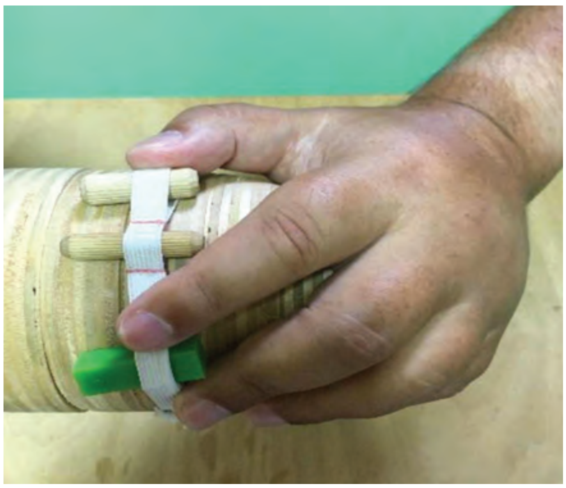

Figure 4 - Exercise with blocks. The patient is seated in a symmetrical position, with the feet placed on the floor; hips, knees and ankles flexed at 90°; the impaired forearm is pronated or partially supine on the UOVO with a carpometacarpal grip. The task involves placing the fingers on counting blocks of various heights and with various surfaces. In this case, the task is to identify the spatial relation between the different fingers. The exercise is performed at the first level (see text). By unblocking the individual modules that make up the egg, it is possible to vary to pronation and supination position of the hand.

In accordance with the recommendations of the Declaration of Helsinki concerning the ethical principles for medical research involving human subjects, we obtained approval for this longitudinal experimental case report from the ethics committee of the School of Physiotherapy of S. Filippo Neri Hospital, "Sapienza" University of Rome, and the patient's written informed consent to his participation in the study and the publication of this observational case report.

## Results

The patient was evaluated at T0, T1 and T2 with the Barthel Index, VAS, MAS for shoulder, elbow and wrist, DASH, MI and FMAS. These evaluations showed improvements in motor functions, spasticity of shoulder, elbow and wrist, motricity and performance in activities of daily living (Table I). The patient obtained a better stabilization of his left hand grip without increasing spasticity.

## Discussion

The UOVO, thanks to its shape and versatility, can be used to perform exercises that stimulate the palmar or cylindrical grip, the metacarpal grip, and opposition of the fingers. Positive results were obtained in terms of recovery of hemiplegic hand grip without increased spasticity: kinesthetic and tactile exercises together with motor exercises integrated with motor imagery were found to be efficacious. The UOVO allowed the patient to work carefully on some elements crucial to the quality of motor imagery in rehabilitation such as "description, timing and behaviour modification" in the context of neurocognitive exercises (Zangrando et al., 2015). Above all, the patient's description of the movement related to a given exercise helps the physiotherapist and physiatrist to understand whether the patient imagines that exercise correctly and how he/she may perform it (Zangrando et al., 2014).

In our case report, the UOVO and motor imagery rehabilitation sequence improved hand function without creating maladaptive compensations and it also decreased spasticity and pain. Through mental images, situations and actions can be anticipated, allowing formulation of the behavioral strategies to be adopted. The image bridges "perception and memory" and "perception and motor control". If the image is altered, our perception changes, and thus, the perception is conditioned by the image (Deschaumes-Molinaro et al., 1992).

The changes that we observed support the suggestion that a neurocognitive rehabilitation program that includes somatosensory and proprioceptive stimuli effects greater recovery of hand motor function (Grant et al., 2017). Moreover, experimental findings indicate that cortical and cerebellar functional reorganization following mental practice improves hand function after stroke (Liu et al., 2014). Other research has provided novel evidence indicating that training involving specific, graded discrimination tasks, attentive exploration of stimuli with vision occluded, deliberate anticipation, and quantitative feedback for hand grip should be encouraged (Carey et al., 2011, 1993).

During the neurocognitive rehabilitation treatment, the physiotherapist must focus on the patient's sensations during the movement, both in exercises for tactile surface discrimination and in ones for joint movement discrimination: the patient should always be asked to recognize the change between the presence and absence of movement ("Tell me when you feel the change") or of contact ("Tell me if you feel there is an area in contact with your palm and fingers"). The effectiveness of sensory re-learning in combination with task-specific training on UL functioning after stroke is also underlined in the literature (Carlsson et al., 2018; Westlake and Byl, 2013).

We thus conclude that the clinical outcome of our patient improved through rehabilitation, even though the treatment was administered only several months after the acute event. It is important to underline the need for continued development of improved rehabilitation techniques in stroke, including methods that do not focus entirely on motor output.

In conclusion, our findings suggest that a neurocognitive rehabilitation approach based on dual-task exercises (involving motor and somatosensory stimulation) and the use of an original rehabilitation aid named UOVO, which lends itself very well to exercises proposed through the use of motor imagery, is effective in promoting functional recovery of hand grip after stroke.

Although the results of our case report are highly encouraging, additional studies are needed to confirm our findings and explore the contributions of motor imagery

Table I - Patient's performance on clinical and functional scales before and after rehabilitation

| Evaluation Scale | | T0 | T1 | T2 |
|---|---|---|---|---|
| Barthel Index | | 78 | 80 | 86 |
| VAS (cm) left UL | | 6 | 4 | 2 |
| MAS left UL | | | | |
| | shoulder | 3 | 1 | 1 |
| | elbow | 2 | 1 | 0 |
| | wrist | 2 | 1 | 0 |
| DASH (%) left UL | | 56 | 46 | 31 |
| MI left UL | | 55/100 | 69/100 | 72/100 |
| FMAS left UL motricity | | 30/66 | 38/66 | 50/66 |

Abbreviations: UL, upper limb; VAS, visual analog scale; MAS, Modified Ashworth Scale; DASH, Disabilities of the Arm, Shoulder and Hand; MI, Motricity Index; FMAS=Fugl-Meyer Assessment Scale; T0, baseline; T1, after 4 weeks; T2, end of treatment.

*versus* tactile and motor function rehabilitation training. More controlled studies in larger samples of patients and with medium-term to long-term follow-ups are needed to identify clinical predictors of the outcome of this rehabilitation protocol.

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