ORIGINAL ARTICLE

# Effects of Sensory Cueing on Voluntary Arm Use for Patients With Chronic Stroke: A Preliminary Study

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ABSTRACT. Fong KN, Lo PC, Yu YS, Cheuk CK, Tsang TH, Po AS, Chan CC. Effects of sensory cueing on voluntary arm use for patients with chronic stroke: a preliminary study. Arch Phys Med Rehabil 2011;92:15-23.

**Objective:** To investigate the effect of a 2-week program of sensory cueing in which vibration induces the use of the paretic upper extremity in participants with chronic stroke in the community.

**Design:** A single-group longitudinal study.

**Setting:** Self-help organizations.

**Participants:** A convenience sample of 16 community residents (N=16) with chronic unilateral stroke and mild to moderate upper-extremity impairment stratified by the severity of their paretic arm function, measured by using the Functional Test for the Hemiplegic Upper Extremity (FTHUE).

**Interventions:** Participants engaged in repetitive upper-extremity task practice for 2 weeks while wearing an ambulatory sensory cueing device on their affected hand for 3 hours a day.

**Main Outcome Measures:** Evaluations were conducted on the 3 occasions of pretest (1 day before training), posttest (immediately after training), and follow-up test (2 weeks after training) by using the following behavioral measures of paretic upper-extremity performance: the Action Research Arm Test (ARAT), the Box and Block Test, the Fugl-Meyer Assessment (FMA), the FTHUE, power and pinch grips, the Motor Activity Log assessment of arm use, and kinematic data obtained from the device.

**Results:** Significant differences were found in ARAT and FMA scores among the pretest, posttest, and follow-up evaluations. The lower functioning group achieved a more significant increase in overall upper-extremity score than in the hand score for the FMA.

**Conclusion:** A combination of sensory cueing and movement-based strategies is useful and feasible in improving paretic upper-extremity performance in participants with chronic stroke; however, additional studies with a larger sample size and longer treatment period in a randomized controlled trial would be beneficial.

**Key Words:** Chronic stroke; Learned nonuse; Paretic upper extremity; Rehabilitation; Sensory cueing; Voluntary arm use.



STROKE IS THE MOST significant cause of severe disability and results in many chronically disabled patients in the population.[1] Functional recovery of the paretic upper extremity after stroke often is slower than that of the lower extremity and is 1 of the greatest challenges faced by rehabilitation professionals.[2] More than 60% of patients with chronic stroke have motor dysfunction in their upper extremities, with only 5% showing complete functional recovery.[3]

One of the biggest problems arising in upper-extremity rehabilitation after stroke is "learned nonuse," in which some of the patient's motor impairment is caused by the learned suppression of movement rather than brain cell damage.[4] One of the main advances made in recent years has been the introduction of CIMT to overcome the learned nonuse of the paretic limbs in daily living activities in the home.[5] CIMT involves restraint of the unaffected limb in either a mitt or sling for 90% of waking hours over a number of weeks and training of the paretic limb during the treatment period,[6] or its modified version, involving different levels of intensity through variation in the duration and frequency of sessions and in total treatment duration.[7-10] It now is clear that the phenomenon underlying CIMT is that it repeatedly induces the use of the paretic arm in task-specific functions and involves the upper extremities in intensive practice, even where they reach a performance plateau.[11-13] Although CIMT is highly efficacious for stroke survivors who show some voluntary wrist and finger extension,[5] it may not be so in patients with chronic stroke with moderate to severe impairment or poorer functioning of the affected upper extremity.[14,15] CIMT also may be difficult to carry out because of safety concerns, especially for patients who have difficulty with balance and therefore may be at risk for falling when the less-affected arm is restrained.[9,13] It also is awkward for patients to walk outdoors with a limb restrained in a mitt.

Other effective treatments that use different theoretical approaches have been used to tackle upper-extremity impairment, including neurofacilitation techniques, repetitive bilateral arm training, and robot-aided exercise training. However, these approaches may require a number of costly therapy hours and expensive equipment. An effective self-administered home exercise program recently has been developed for upper-extremity recovery in patients with stroke, but it still requires staff to teach and monitor closely and the patient has to be very

**List of Abbreviations**

| | |
|---|---|
| AOU | amount of use |
| ARAT | Action Research Arm Test |
| BBT | Box and Block Test |
| CIMT | constraint-induced movement therapy |
| FMA | Fugl-Meyer Assessment |
| FTHUE | Functional Test for the Hemiplegic Upper Extremity |
| MAL | Motor Activity Log |
| QOM | quality of movement |

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motivated to continue with the treatment at home for 3 months.[16]

Previous findings have reported the use of an external limb activation device that is strapped to the hemiplegic arm and provides an auditory alert signal to alleviate the problem of unilateral neglect in stroke patients.[17-20] In a previous study, we explored the effects of using external sensory signals on a device to provide a sensory cue to the paretic upper extremity of subacute patients poststroke with unilateral neglect. We found that when the patient is appropriately trained, use of external signals promotes the patient's awareness of their hemiplegic field and improves the initiation of movements and learned use of the paretic limb for daily functions.[21] In the study reported here, we sought to substantiate an innovative treatment that involves promoting the awareness of and overcoming learned nonuse of the paretic upper extremity in patients with chronic stroke by activating the affected limb through a sensory cue emitted by a portable wristwatch device strapped to the forearm. We taught participants how to carry out upper-limb movement tasks for the paretic limb according to a protocol we designed by reference to the main therapeutic factor of awareness resulting from sensory cueing. This treatment would save the cost of intensive training involving supervised therapy and its results would represent a significant contribution to both the use of cost-effective strategies and treatment of learned nonuse to promote paretic upper-extremity function in the field of stroke rehabilitation. We hypothesized that a 2-week program of sensory cueing in which vibration induces the use of the paretic upper extremity and an ambulatory wristwatch device is used to remind patients to move would promote recovery of the paretic upper extremity in participants with chronic stroke.

## METHODS

### Participants

A single-group longitudinal design was adopted for this study. A convenience sample of 16 community residents with chronic unilateral stroke from 3 self-help groups for stroke survivors in Hong Kong was recruited for the study from September 2008 to August 2009. Inclusion criteria were as follows: (1) first-time ischemic or hemorrhagic stroke; (2) stroke with unilateral hemispherical involvement; (3) aged 18 years or older; (4) chronic stroke (ie, stroke onset) more than 6 months before the study; (5) moderate to mild unilateral upper-limb paresis determined by using the FTHUE[22,23] (FTHUE level $\geq$ 3), with volitional elbow flexion/extension to initiate forearm pronation/supination and flexion/extension of the wrist; (6) able to understand verbal instructions and follow 1-step commands; (7) no excessive spasticity, defined as a score higher than 3 on the Modified Ashworth Scale[24]; (9) no excessive pain or swelling over the paretic upper extremity; (10) no prior participation in experimental or drug studies; and (11) able to understand the meaning of the study and give informed consent to participate. Potential participants were excluded if they (1) scored less than 22 on the Mini-Mental State Examination[25]; (2) showed inadequate balance, indicated by inability to stand for at least 2 minutes with or without upper-extremity support; or (3) showed unilateral neglect, assessed by using the letter cancellation and line bisection subtests of the Behavioral Inattention Test.[26,27] The choice of a poststroke period of 6 months or more as an inclusion criterion for chronic stroke reflected the probability that any spontaneous recovery would have slowed down by the time of the study, thus enabling more brain reorganization in response to the therapeutic intervention under study. To investigate which level of severity of paretic upper-extremity functional impairment would benefit most from the treatment, participants were stratified further into 2 groups for additional analysis according to whether their upper-extremity impairment was moderate or mild. Group 1, the lower functioning group, included 8 participants with moderate impairment to a paretic upper extremity (ie, FTHUE levels of 3–4) who were able to show a mass flexion pattern in the shoulder of 30° to 60° and at the elbow of 60° to 100°, gross grasp of 3 to 5 pounds, and mild lateral pinch. Group 2, the higher functioning group, included 8 participants with mild upper-extremity paresis (ie, FTHUE level $\geq$ 5) who were able to show a beginning ability to combine components of strong mass flexion and strong mass extension patterns and were able to perform some release of the hand, as well as isolated control of all upper-extremity musculature with fair strength. Written and informed consent was obtained from all participants before the study started. The study was carried out in accordance with the principles of the Declaration of Helsinki. Ethical approval was sought and obtained from the Hong Kong Polytechnic University (Reference: HSEAR20080829001).

### Sensory Cueing Device

The only piece of equipment used for sensory cueing was the sensory cueing wristwatch (SCW-V2),[a] which is designed to provide pertinent electronic sensory signals to patients with hemiplegia to increase their awareness of the paretic limb (fig 1). The SCW-V2 is small, lightweight (78g), user friendly, and easy to secure comfortably to the wrist by using nonallergenic neoprene straps with a Velcro closure. It can be set to emit a sensory signal in the form of a vibration cue (196Hz, similar to the vibration mode of a mobile telephone). This signal occurs within a predetermined variable (or random) time that ranges from a few seconds to several minutes. Built into the device is an acknowledgement button that is used to stop the signal and that will be activated continuously as long as the button is not pressed. This means that a wearer who wants to stop the cues must press the button as soon as possible. The SCW-V2 has a built-in logger to detect the amount of upper-extremity movement in the X, Y, and Z directions and the speed at which the signal is switched off, which indicates reaction time to the cue. Movement acceleration is sampled at a range of 1 to 10Hz and summed as a raw count over a user-specified epoch period that varies from 1 second to 60 minutes. The device, which is

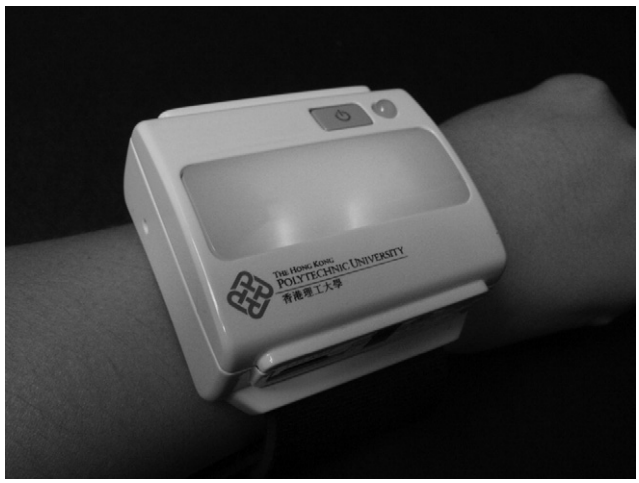


**Fig 1. View of the device from above to show the acknowledgement button and how it is worn on the wrist.**