Acceptability of constraint induced movement therapy: influence of perceived difficulty and expected treatment outcome

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ABSTRACT

Background: Constraint-Induced Movement (CI) Therapy has evidence of efficaciously rehabilitating upper-extremity hemiparesis after stroke. Yet, it is not widely used in the United States. One barrier appears to be the perception of its difficulty among stroke care consumers, as reported by two published studies in which the participants had little or no apparent direct exposure to CI Therapy.

Objectives: Assess the perception of difficulty of CI Therapy by individuals with chronic stroke who have actually undergone CI Therapy.

Methods: A secondary analysis was conducted of data from two randomized controlled trials of CI Therapy. Participants had chronic, mild-to-moderate upper-extremity hemiparesis after stroke. The Motor Activity Log and Wolf Motor Function Test were used to measure motor function of the more-affected arm. A Patient Opinion Survey assessed participants’ perception of difficulty and satisfaction with treatment.

Results: The participants (N = 40) showed large improvements in motor function of their more-affected arm after treatment, p's <.001. CI Therapy was perceived to be of only moderate difficulty by participants before treatment (mean = 4.4 out of 7). Perception of its difficulty decreased afterward (mean = 3.7, p = .002). Moreover, participants were highly satisfied with their outcomes (mean = 6.3 out of 7). Satisfaction was positively related to the improvements in more-affected arm use in everyday life, AR^2 = .3, p < .001.

Conclusions: Chronic stroke survivors who have actually had CI Therapy perceive it to be of only moderate difficulty and are highly satisfied. Negative views about its acceptability warrant reconsideration.

Introduction

Among the factors that influence the decision of a healthcare consumer to undertake a course of treatment are the perception of the difficulty of that treatment balanced against the benefits of the expected outcome. A similar balance of factors informs the decision of a therapist to offer a particular treatment or to refer a healthcare consumer to a clinician experienced in its procedures. Thus, if the expected satisfaction with outcome were substantial, it might override the perception that a treatment would be difficult, which would be likely to strongly influence the decision to embark on or provide or recommend that treatment. For the purpose of the present discussion, the term “acceptability” is meant to be the likelihood of undertaking any of these actions or all of them combined. Consumer acceptability of a treatment has two aspects: willingness to participate in treatment before initiation and willingness to complete treatment after initiation.

Rehabilitation services in general require considerable effort and are sometimes perceived to be difficult. They are therefore not accepted well by many prospective consumers. However, the acceptability of services is also influenced by the expected satisfaction with treatment outcome. Thus, in trying to assess the potential acceptability of a rehabilitation treatment to either healthcare consumer or therapist, it is important to consider

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both whether a treatment is perceived as arduous and the expected satisfaction with the outcome of that treatment. If the expected satisfaction with outcome was substantial, it might override the perception that a treatment will be difficult in determining that treatment’s acceptability.

A specific case illustrating the interaction of these competing influences is Constraint-Induced Movement Therapy (CI Therapy). CI Therapy is a family of rehabilitation treatments derived from basic behavioral neuroscience research with primates. Work in this laboratory, derived from that research, began with individuals with chronic stroke. Approximately 1000 adults with chronic stroke and 800 children with cerebral palsy have undergone upper-extremity CI Therapy in our laboratory and clinic; clinically meaningful improvements were recorded in more than 97% of these cases (summarized in ). The within group effect size ($d$ varied across studies from 2.1 to 3.6 (large $d = 0.56$). More than 500 CI Therapy studies have been published and the great majority have reported positive results. A Cochrane review reported that “CI Therapy produces clinically meaningful improvement in speed of task completion and significantly increases the ease of the affected upper limb in everyday life.” Notably, these findings have been borne out in a blinded multisite randomized controlled trial of CI Therapy with subacute stroke survivors. The gains were sustained without decrement over the 1-year of follow up. The CI Therapy protocol has been applied with similar success to the upper-extremities after traumatic brain injury, multiple sclerosis, and cerebral palsy and other pediatric neurological disorders to the lower extremities after stroke, cerebral palsy, multiple sclerosis, spinal cord injury and fractured hip (summarized in ) and to speech after stroke.

Notwithstanding, the extensive demonstration of efficacy of CI Therapy for a variety of deficits in various diagnostic categories, the technique is not used extensively in the United States. There are several likely reasons for this: 1) a non-traditional massed schedule of delivery of services, 2) the initial sparseness of insurance coverage, and 3) a perception that the treatment is excessively difficult to undergo. The perception of difficulty appears to be based at least in part on early studies in which groups of therapists and stroke care consumers responded to a questionnaire concerning their understanding of the difficulty of the treatment. However, there is little information in the papers about the prior experience of the survey respondents with CI Therapy or what survey respondents were told about CI Therapy before completing the questionnaires. Both Page et al. and Daniel et al. indicate that therapists were not required to have experience administering CI Therapy but instead had to be familiar with the intervention from attending inservices or continuing education lectures or reading the scientific literature. Daniel et al. shares that therapists were provided with a description of CI Therapy from a published study along with information about its efficacy. No information is provided in Page et al. about what the stroke care consumers were told about CI Therapy or about their prior experience with CI Therapy. However, given that the Page et al. data were collected before August 2000, it is very unlikely that any of the consumers had received CI Therapy. Except for a handful of places, CI Therapy was not offered on a clinical basis in the United States at that time. Daniel et al. surveyed only therapists. Thus, the opinions of the Page et al. and Daniel et al. survey respondents may not accurately reflect the experience of therapists and healthcare consumers actually exposed to the therapy.

The present study was undertaken to determine the 1) nature of the perception of difficulty of CI Therapy among individuals with stroke who are about to undergo the treatment and who are given both an accurate description of the nature of its procedures and the average treatment outcomes from previous studies, and 2) satisfaction with outcomes that these individuals had after treatment. In addition, we sought to determine whether the perception of difficulty changed after treatment, i.e. whether the experienced benefit differed from the anticipated benefit.

**Methods**

**Participants**

Analysis was carried out of data gathered from participants with upper-extremity hemiparesis due to chronic stroke who had been treated with two different but closely related forms of CI Therapy in previous studies: standard CI Therapy (delivered without an automated device) and CI Therapy...
delivered on a distance basis by a therapist with the aid of an automated device termed Automated CI Therapy Extender (AutoCITE).\textsuperscript{25} Except for the type of delivery of therapy, these two studies were the same in participant recruitment, inclusion and exclusion criteria, and measurement. Written informed consent was obtained from the participants prior to enrollment; the studies were approved by the University of Alabama at Birmingham Institutional Review Board (FWA00005960). This manuscript was prepared according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Recruitment for these studies was carried out primarily by physician and therapist referral. A physical therapist and a neurologist performed the screening of all candidate participants.

Inclusion criteria were: 1) a diagnosis of stroke at least 1 year prior to the study, 2) mild to moderate hemiparesis defined on the basis of active range of motion,\textsuperscript{28} 3) preserved ability to comprehend and participate in basic elements of the therapy, 4) English as a first language.

Exclusion criteria were: 1) motor function that is too high in the performance of the activities of daily living (ADL) in everyday situations (scores above 2.5 on the 5-point Arm Use Scale of the Motor Activity Log), 2) uncontrolled medical conditions or frailty that would prevent intensive rehabilitation, 3) profound bilateral hearing loss with use of hearing aids (90 dB or worse), 4) legally blind status, 5) previous CI Therapy, 6) concurrent participation in other experimental rehabilitation trials, 7) any pharmacological treatment for motor disability ≤3 months before treatment, including botox or oral intrathecal baclofen.

Interventions

As noted participants were recruited from two different studies in which two different, related forms of CI Therapy were administered.

Standard CI Therapy (i.e., delivered without an automated device). All participants in this study received CI Therapy for 10 consecutive weekdays. CI Therapy consists of four main components:\textsuperscript{28} 1) an intensive training program for the more-affected upper extremity, 2) training by the behavioral training technique of shaping based on principles formulated by Skinner\textsuperscript{29,30} and modified for use in a physical rehabilitation context,\textsuperscript{31} 3) a set of behavioral procedures to facilitate the transfer of motor improvement from the laboratory to the life situation termed the Transfer Package,\textsuperscript{28} 4) restraint of the less affected hand by a heavily padded mitt for a target of 90% of waking hours to encourage use of the hemiparetic upper extremity for ADL. The Transfer Package\textsuperscript{28} is a particularly important component of the treatment; it consists of commonly used techniques derived from the field of behavior analysis including: 1) a behavior contract; 2) a daily home diary keyed to the behavior contract; 3) daily administration of the Motor Activity Log (MAL), a scripted structured interview concerning spontaneous use of the more affected arm in ADL in everyday situations (to focus frequent attention on using that extremity outside the treatment setting); 4) problem solving during the daily MAL administration and review of the daily diary to overcome perceived (or real) barriers to the use of the more affected arm in everyday situations; 5) daily written homework assignment of 10 activities in which the more affected arm should be used outside the treatment setting with a check-off component on the assignment sheet so that compliance can be monitored each treatment day. Treatment in the laboratory was 3.5 hours/day with frequent rest intervals given as needed. Further details of the method are provided elsewhere.\textsuperscript{28,32}

Automated CI Therapy or CI Therapy delivered with the aid of AutoCITE. Participants receiving CI Therapy with AutoCITE received the same treatment as standard CI Therapy but at home at a workstation. A trainer in the laboratory supervised participants via an internet-based audiovisual and data link. In addition, a software package was used to track the participants’ performance, provide feedback and pace therapy.\textsuperscript{25}

Outcome measures

Data were collected immediately before and after the treatment using the Participant Opinion Survey, Motor Activity Log and Wolf Motor Function Test.
Participant Opinion Survey (POS). The POS consists of items that elicit information about the perceived difficulty of and satisfaction with the therapy. Before administration, the participant is given a 1-page single spaced description of CI Therapy. The sections of the description are labeled “What is CI Therapy,” “The Process,” “Why it Works” (which explains overcoming learned non-use and brain plasticity, the two processes shown in multiple experiments to be associated with the improved function produced by the treatment) and “Results” (in which information is given about the percentage of participants who have shown substantial improvement in “weaker limb function” as a result of the treatment). Two versions of the POS are given. The pretreatment version asks in separate questions how difficult, frustrating, and beneficial they think the treatment will be and how beneficial a significant other or caregiver (if there is one) thinks it will be. The post-treatment version of the POS asks the same questions in the past tense. Answers are recorded on 7-point Likert scales, with “7” indicating, Extremely Difficult/Frustrating or Strongly Agree (that the program will be of benefit) and “1” indicating, Not at All Difficult/Frustrating or Strongly Disagree (that the program will be of benefit). The neutral mid-point is “4,” which is unlabeled. The CI Therapy description given to patients and the survey are presented in the Appendix.

Motor Activity Log (MAL). Treatment outcome was measured by the MAL. As noted, the MAL is a scripted, structured interview that quantifies the amount and quantity of spontaneous real-world use of the more affected arm. It is a widely used instrument with an established validity and reliability. Participants are asked to rate the amount of use (AOU) and quality of movement (QOM) of their arm more affected by stroke in 30 common and important daily life activities over a specified period (e.g. yesterday, since the last time we met, last week). The AOU and QOM scales employ 11-point Likert scales. Only scores from the QOM scale, referred to here as the Arm Use Scale, are reported because QOM and AOU scores are highly correlated. The test score is the mean of the item scores. The minimum detectable change on MAL has been found to be 0.5 points, which is 10% of full-scale range.

Wolf Motor Function Test (WMFT). Motor capacity of the more affected arm in a clinical setting was measured by the WMFT. The WMFT is a valid and reliable measure of in-laboratory motor function capacity (maximum capacity) when a participant is asked to complete a task with a more affected arm. The WMFT consists of 15 functional tasks that are timed. The test score is the mean of the item performance time scores after transforming them into a rate (repetitions per minute). Items that cannot be completed in 120 s are assigned a score of 0.

Preliminary data analysis

Preliminary analyses showed that participants in both studies were similar in terms of age, gender, ethnicity, race, more dominant side affected by stroke and time since stroke \((p > .05)\). Both participant groups were similar in the pre-treatment and post-treatment motor ability of the more affected arm and the perception of difficulty of CI Therapy on the pretreatment POS. There was no significant difference between groups in treatment outcome and post-treatment satisfaction with CI Therapy \((p > .05)\). Therefore, the two datasets were merged to conduct the final analysis.

Data analysis

To determine if there was any change on the POS in participants’ perception of difficulty from before treatment (anticipated) to after treatment (experienced), a paired t-test was employed. Paired t-tests were also used to evaluate changes in the outcome measures from pre- to post-treatment. To communicate the size of any changes observed, we calculated Cohen’s \(d'\), which is repeated-measures index of effect size. Small, medium, and large values of \(d'\) are thought to be 0.2, 0.5, and 0.8, respectively. To determine if participants perceived CI Therapy to be satisfying, the mean of the post-treatment satisfaction scores on the POS was calculated. Hierarchical regression models were used to test if there is a relationship between amount of satisfaction registered on the POS and the magnitude of the gain in use of their more-affected arm resulting from treatment as indicated by change in MAL score from before to after.
treatment. Parallel models were used to test if there is a relationship between amount of satisfaction registered on the POS and the magnitude of the gain in use of their more-affected arm in the treatment setting as indicated by change in WMFT score from before to after treatment. Two-tailed tests with an α of .05 were used.

Results
Twenty-one participants were enrolled in the standard in-person therapy and 20 participants were enrolled in the AutoCITE study. All but one participant given the in-person intervention and all AutoCITE participants completed the treatment. In total, there were 40 participants in the final dataset. Mean age was 60 years (range = 29 to 94 years; SD = 12.7); 22 (53.7%) were females. For 24 (58%) participants, the left upper extremity was more affected by stroke; for 17 (42%), the dominant hand was more affected by stroke.

Following treatment, participants had a significant improvement in the real-world use of the more affected arm, \( t(39) = 15.4, p < .001, d^* = 2.4 \). The Arm Use Scale score increased 2.2 points (SD = 0.9) from a mean of 1.1 (SD = 0.6) before treatment to 3.3 (SD = 0.9) afterward. That is, use of the more-affected upper extremity in everyday situations outside the treatment setting went from approximately 12% before stroke to 53% after treatment, an approximate 4.4 times increase. In two previous studies, the effect size (\( d \)) of treatment change was 3.7 and 2.3. The participants also had a significant improvement in motor capacity of their more-affected arm in the treatment setting, \( t(39) = 4.9, p < .001, d^* = 0.8 \). Performance Rate scores on the WMFT increased 7.3 repetitions per minute (SD = 8.8) from a mean of 31.2 (SD = 13.8) before treatment to 38.8 (SD = 15.5) afterward.

Before the beginning of treatment, participants perceived CI Therapy to be of moderate difficulty; mean POS scale score = 4.4, SD = 1.6, range = 1 to 7. After treatment, there was a significant decrease in their perception of its difficulty, to 3.7, below the neutral anchor of the scale, mean change = −0.7, \( SD = 1.6, t(38) = −2.4, p = .002 \). After treatment, the overall satisfaction scores indicated that the participants were highly satisfied with CI Therapy (\( M = 6.3 \) of 7.0, \( SD = 0.8 \)). As noted, the MAL obtains information about the actual use of the more affected arm in everyday situations outside the treatment setting. Using participants’ pretest Arm Use scores on the MAL as a covariate in a hierarchical multiple regression model, the test revealed that for every one point gain in the Arm Use Scale, there was a 0.6 point gain in overall satisfaction; \( \beta = 0.6, \Delta R^2 = .3, F(1,29) = 13.6, p < .001 \). In contrast are the results for the WMFT, which is a measure of maximum motor ability when optimal performance is requested by a tester. Using participants’ pretest WMFT Performance Rate scores as a covariate in a hierarchical multiple regression model, there was no association between overall satisfaction and gain after CI Therapy in how quickly tasks were performed with the more affected arm in the treatment setting; \( \Delta R^2 = 0, F(1,30) = 0, p = .941 \). That is, the increase in Performance Rate in a laboratory motor test did not explain a significant proportion of variance in overall satisfaction in the therapy, while the amount that the more-affected arm was actually used in the life situation did.

Discussion
Participants with chronic stroke who were about to undergo CI Therapy and who were given accurate information about the nature of the therapy procedures anticipated that it would be of only moderate difficulty. This is contrary to the opinions expressed by therapists with little or no direct experience of CI Therapy reported earlier, and which appears to have been influential in reducing the apparent acceptability of this treatment for referral or use in a clinical setting. The fact that the participants in this study did not find CI Therapy to be difficult is supported by the finding that 98% of them completed therapy; only one participant dropped out of treatment. This is consistent with the literature suggesting that when tasks are of only moderate difficulty, participant engagement is maximal. A further consideration is that CI Therapy has been shown to decrease depressive symptom severity. A therapy that elevates mood would
presumably not be perceived as having been exces-
sively difficult by consumers who have received it.

We also found that the perceived difficulty of CI
Therapy by participants was lower after treatment
than beforehand. Previous research indicates that
when the perceived difficulty of a task falls, individ-
uals are more likely to engage in the task. In
addition, when an increase in ability takes place,
perceived difficulty decreases.41 These two
dynamics support the engagement of participants
in training that places high demands on them.43

A number of aspects of CI Therapy are designed
to reduce participants’ experience of difficulty dur-
ing task performance. One of these strategies is the
use of the behavioral technique of shaping29,30 dur-
ing training. Shaping begins with a request for the
participants’ best performance. Participants are
then encouraged to improve on that in small steps
by what are termed “successive approximations” so
that task requirements are always within partici-
pants’ motor capacity. This would not be the case
if the ultimate task objective were presented as an
immediate goal. In addition, participants are
warmly rewarded when improvements occur and
performance regressions are either de-emphasized
or not commented on.

Problem solving is another aspect of the CI
Therapy Transfer Package protocol;28 it is designed
to reduce task difficulty and overcome barriers to
improved motor performance in everyday situa-
tions outside the treatment setting. At the begin-
ing of each treatment session, therapists
administer the MAL and review the daily diary
and performance of the homework tasks previously
assigned. When therapists find that a participant
has not performed a task that they have been
observed to be capable of in the laboratory, they
attempt to determine why in a non-
confrontational, helpful fashion. There are usually
standard reasons for nonperformance such as social
embarrassment, frustration with slow or clumsy
execution, or forgetting to perform tasks that had
not been carried out for an extended period since
stroke onset. The CI Therapy clinician, who has
encountered these explanations many times before,
has a standard set of helpful solutions to offer. In
this regard, participants are encouraged to proac-
tively use, “if-then” behavior plans to facilitate
accomplishing effective performance in everyday

situations.44 That is, “if” a situation arises where
difficulties have been encountered previously in
effectively using the more-affected extremity,
“then” the participant is instructed to use a
predetermined, safe strategy to accomplish the
task. For example, “if” there is concern about spil-
ing of liquid when drinking from a glass, “then” the
glass should only be filled up partway.

Consumer satisfaction has been demonstrated to
be related to multiple features of healthcare
services.45 One important factor is the amount of
gain in treatment outcome.46–48 In accord with
previous studies (e.g. Taub et al., 1993,10 2006,49
201328) we found that participants after CI Therapy
had a large and significant improvement on the
MAL, which measures use of the more-affected
arm in daily life. We also found that participants
were highly satisfied with their treatment. Further,
there was a significant positive relationship
between participants’ overall satisfaction with the
therapy and their gain in use of their more-affected
arm in real-life situations. Of interest, their overall
satisfaction with treatment was not found to be
related to gain in the motor capacity of their more-
affected arm as measured by the WMFT (as
distinguished from use of the more-affected arm in
real life situations). Thus, as noted above, the gain
in the use of the more-affected arm in real life
situations is particularly important for consumer
satisfaction with CI Therapy as compared with
improvement in maximum motor capacity exhib-
ited in the laboratory. This finding is consistent
with a study that found improvements after CI
Therapy in quality of life were associated with
improvements on the MAL but not the WMFT50
and is consistent with the results for another
therapy.26,27,47

In summary, the presumed difficulty of CI
Therapy has been reported to be an important
barrier to its acceptability in two studies based on
the opinion of individuals with no apparent direct
experience with the treatment.26,27 The current
study has explored the nature of the perceived
difficulty of CI Therapy when accurate information
about its procedures and expected outcome are
provided to consumers before undergoing the
treatment. The study found that participants with
stroke who have actually experienced CI Therapy
when this type of veridical information was
provided beforehand found this treatment to be of only moderate difficulty. Moreover, after CI Therapy, participants’ perception of its difficulty actually decreased. In addition, satisfaction with treatment outcome was high.

**Implications**

Our findings suggest the balance between the perceived difficulty and expected benefit from CI therapy is more favorable than in previous reports. Given this set of results, therapists and consumers might re-examine their view of the acceptability of CI therapy. Therapists who had not included CI therapy as a treatment option for adults with chronic, mild-to-moderate, post-stroke upper-extremity hemiparesis because they thought it was unacceptable to consumers might now consider doing so. If so, therapists, in addition to summarizing the literature on the efficacy of CI therapy, might share the findings of this study; i.e. individuals who had had CI therapy found it only of moderate difficulty and were highly satisfied with their outcomes.

**List of abbreviations**

| Abbreviation | Description |
|--------------|-------------|
| ADL          | Activities of Daily Living |
| AOU          | Amount of Use |
| AutoCITE     | Automated Constraint-Induced Therapy Extension |
| CI Therapy   | Constraint-Induced Movement Therapy |
| MAL          | Motor Activity Log |
| POS          | Patient Opinion Survey |
| QOM          | Quality of Movement |
| WMFT         | Wolf Motor Function Test |

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**References**

1. Conoley CW, Conoley JC, Ivey DC, Scheel MJ. Enhancing consultation by matching the consultee’s perspectives. *J Couns Dev*. 1991;69(6):546–549. doi:10.1002/j.1556-6676.1991.tb02639.x.
2. Scheel M, Seaman S, Roach K, Mullin T, Mahoney K, Hill CE. Client implementation of therapist recommendations predicted by client perception of fit, difficulty of implementation, and therapist influence. *J Couns Psychol*. 1999;46(3):308–316. doi:10.1037/0022-0167.46.3.308.
3. Asano M, Duquette P, Andersen R, Lapierre Y, Mayo NE. Exercise barriers and preferences among women and men with multiple sclerosis. *Disabil Rehabil*. 2013;35(5):353–361. doi:10.3109/09638288.2012.742574.
4. Kersten P, McPherson KM, Kayes NM, Theadom A, McCambridge A. Bridging the goal intention–action gap in rehabilitation: a study of if-then implementation intentions in neurorehabilitation. *Disabil Rehabil*. 2015;37(12):1073–1081. doi:10.3109/09638288.2014.955137.
5. Zimmerli L, Krewer C, Gassert R, Müller F, Riener R, Lünenburger L. Validation of a mechanism to balance exercise difficulty in robot-assisted upper-extremity rehabilitation after stroke. *J Neuroeng Rehabil*. 2012;9(1):6. doi:10.1186/1743-0003-9-6.
6. Greenberg J, Prushinsky O, Harris JD, et al. Utilization of a patient-centered asthma passport tool in a subspecialty clinic. *J Asthma*. 2018;55(2):180–187. doi:10.1080/02770903.2017.1323916.
7. Hofer R, Choi H, Mase R, Fagerlin A, Spencer M, Heisler M. Mediators and moderators of improvements in medication adherence: secondary analysis of a community health worker-led diabetes medication self-management support program. *Health Educ Behav*. 2017;44(2):285–296. doi:10.1177/1090198116656331.
8. Taub E. Movement in nonhuman primates deprived of somatosensory feedback. *Exerc Sports Sci Rev*. 1977;4:335–374.
9. Taub E. Somatosensory Deafferentation Research with Monkeys: Implications for Rehabilitation Medicine. *Behavioral Psychology in Rehabilitation Medicine: Clinical Applications*. Philadelphia: Williams and Wilkins; 1980:371–401.
10. Taub E, Miller NE, Novack TA, et al. Technique to improve chronic motor deficit after stroke. *Arch Phys Med Rehabil*. 1993;74:347–354.
11. Lang CE, Edwards DF, Birkenmeier RL, Dromerick AW. Estimating minimal clinically important differences of upper-extremity measures early after stroke. *Arch Phys Med Rehabil*. 2008;89(9):1693–1700. doi:10.1016/j.apmr.2008.02.022.
12. Taub E, Uswatte G. Constraint-Induced Movement therapy: a paradigm for translating advances in behavioral neuroscience into rehabilitation treatments. In: Berntson GG, Cacioppo JT, eds. *Handbook of Neuroscience for the Behavioral Sciences*. Hoboken, NJ: John Wiley & Sons, Inc.; 2009:1296–1314.
13. Hatem SM, Saussez G, Della Faille M, et al. Rehabilitation of motor function after stroke: a multiple systematic review focused on techniques to stimulate upper extremity recovery. *Front Hum Neurosci*. 2016;10:442. doi:10.3389/fnhum.2016.00442.
14. Langhorne P, Coupar F, Pollock A. Motor recovery after stroke: a systematic review. Lancet Neurol. 2009;8(8):741–754. doi:10.1016/S1474-4422(09)70150-4.

15. Raffin E, Hummel FC. Restoring motor functions after stroke: multiple approaches and opportunities. Neuroscientist. 2018;24(4):400–416. doi:10.1177/1073858417737486.

16. Corbetta D, Sirtori V, Castellini G, Moja L, Gatti R. Constraint-Induced Movement therapy for upper extremities in people with stroke. Cochrane Database Syst Rev. 2015;CD004433.

17. Shaw SE, Morris DM, Uswatte G, McKay S, Meythaler JM, Taub E. Constraint-Induced Movement therapy for recovery of upper-limb function following traumatic brain injury. J Rehabil Res Dev. 2005;42(6):769–778. doi:10.1682/JRDR.2005.06.0094.

18. Mark VW, Taub E, Uswatte G, et al. Phase II randomized controlled trial of Constraint-Induced Movement therapy in multiple sclerosis. Part 1: effects on real-world function. Neurorehabil Neural Repair. 2018;32(3):223–232. doi:10.1177/1545968318761050.

19. Taub E, Ramey SL, DeLuca S, Echols K. Efficacy of Constraint-Induced Movement therapy for children with cerebral palsy with asymmetric motor impairment. Pediatrics. 2004;113(2):305–312. doi:10.1542/peds.113.2.305.

20. Taub E, Griffin A, Nick J, Gammons K, Uswatte G, Law CR. Pediatric CI therapy for stroke-induced hemiparesis in young children. Dev Neurorehabil. 2007;10(1):3–18. doi:10.1080/13638490601151836.

21. Johnson ML, Taub E, Harper LH, et al. An enhanced protocol for Constraint-Induced Aphasia therapy II: a case series. Am J Speech Lang Pathol. 2014;23(1):60–72. doi:10.1044/1058-0360(2013)12-0168.

22. Fleet A, Che M, Mackay-Lyons M, et al. Examining the use of constraint-induced movement therapy in Canadian neurological occupational and physical therapy. Physiother Can. 2014;66(1):60–71. doi:10.3138/ptc.2012-61.

23. Pedlow K, Lennon S, Wilson C. Application of Constraint-Induced Movement therapy in clinical practice: an online survey. Arch Phys Med Rehabil. 2014;95(2):276–282. doi:10.1016/j.apmr.2013.08.240.

24. Viana R, Teasell R. Barriers to the implementation of Constraint-Induced Movement therapy into practice. Top Stroke Rehabil. 2012;19(2):104–114. doi:10.1310/tsr1902-104.

25. Taub E, Lum PS, Hardin P, Mark VW, Uswatte G. AutoCITE: automated delivery of CI therapy with reduced effort by therapists. Stroke. 2005;36(6):1301–1304. doi:10.1161/01.STR.0000166043.27545.e8.

26. Daniel L, Howard W, Braun D, Page SJ. Opinions of Constraint-Induced Movement therapy among therapists in southwestern Ohio. Top Stroke Rehabil. 2012;19(3):268–275. doi:10.1310/tsr1903-268.

27. Page SJ, Levine P, Sisto S, Bond Q, Johnston MV. Stroke patients’ and therapists’ opinions of Constraint-Induced Movement therapy. Clin Rehabil. 2002;16(1):55–60. doi:10.1016/0269215502cr475oa.

28. Taub E, Uswatte G, Mark VW, et al. Method for enhancing real-world use of a more affected arm in chronic stroke: transfer package of constraint-induced movement therapy. Stroke. 2013;44(5):1383–1388. doi:10.1161/STROKEAHA.111.000559.

29. Skinner BF. The Behaviour of Organisms. New York: Appleton Century Crofts; 1938.

30. Skinner BF. The Technology of Teaching. New York: Appleton Century Crofts; 1968.

31. Taub E, Crago JE, Burgio LD, et al. An operant approach to rehabilitation medicine: overcoming learned nonuse by shaping. J Exp Anal Behav. 1994;61(2):281–293. doi:10.1901/jeab.1994.61-281.

32. Morris DM, Taub E, Mark VW, et al. Protocol for a randomized controlled trial of CI therapy for rehabilitation of upper extremity motor deficit: the Bringing Rehabilitation to American Veterans Everywhere project. J Head Trauma Rehabil. 2019;34(4):268–279. doi:10.1097/HTR.0000000000000460.

33. Uswatte G, Taub E, Morris D, Light K, Thompson PA. The Motor Activity Log-28: assessing daily use of the hemiparetic arm after stroke. Neurology. 2006;67(7):1189–1194. doi:10.1212/01.wnl.0000238164.90657.c2.

34. Uswatte G, Foo WL, Olmstead H, Lopez K, Holand A, Simms LB. Ambulatory monitoring of arm movement using accelerometry: an objective measure of upper-extremity rehabilitation in persons with chronic stroke. Arch Phys Med Rehabil. 2005;86(7):1498–1501. doi:10.1016/j.apmr.2005.01.010.

35. Van Der Lee JH, Beckerman H, Knol DL, De Vet HCW, Bouter LM. Clinimetric properties of the Motor Activity Log for the assessment of arm use in hemiparetic patients. Stroke. 2004;35(6):1410–1414. doi:10.1161/01.STR.0126900.24964.7e.

36. Wolf SL, Lecraw DE, Barton LA, Jann BB. Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head-injured patients. Exp Neurol. 1989;104(2):125–132. doi:10.1016/S0014-4886(89)80005-6.

37. Morris DM, Uswatte G, Crago JE, Cook EW, Taub E. The reliability of the Wolf Motor Function Test for assessing upper extremity function after stroke. Arch Phys Med Rehabil. 2001;82(6):750–755. doi:10.1053/apmr.2001.23183.

38. Wolf SL, Catlin PA, Ellis M, Archer A, Morgan B, Piacentino A. Assessing Wolf Motor Function Test as outcome measure for research in patients after stroke. Stroke. 2001;32(7):1635–1639. doi:10.1161/01.STR.32.7.1635.

39. Hodics TM, Nakatsuka K, Upreti B, Alex A, Smith PS, Pezzullo JC. Wolf Motor Function Test for characterizing moderate to severe hemiparesis in stroke patients.
40. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

41. Brehm JW, Self EA. The intensity of motivation. *Annu Rev Psychol*. 1989;40(1):109–131. doi:10.1146/annurev.ps.40.020189.000545.

42. Haddad MM, Uswatte G, Taub E, Barghi A, Mark VW. Relation of depressive symptoms to outcome of CI movement therapy after stroke. *Rehabil Psychol*. 2017;62(4):509–515. doi:10.1037/rep0000171.

43. Wright RA, Wadley VG, Pharr RP, Butler M. Interactive influence of self-reported ability and avoidant task demand on anticipatory cardiovascular responsivity. *J Res Pers*. 1994;28(1):68–86. doi:10.1006/jrpe.1994.1007.

44. Freydefont L, Gollwitzer PM, Oettingen G. Goal striving strategies and effort mobilization: when implementation intentions reduce effort-related cardiac activity during task performance. *Int J Psychophysiol*. 2016;107:44–53. doi:10.1016/j.ijpsycho.2016.06.013.

45. Pascoe GC. Patient satisfaction in primary health care: a literature review and analysis. *Eval Program Plann*. 1983;6(3–4):185–210. doi:10.1016/0149-7189(83)90002-2.

46. Cheon JW. Causal relationships between background characteristics, service utilization, satisfaction, and service outcomes (school performance): a path analysis. *Child Youth Serv Rev*. 2009;31(9):957–962. doi:10.1016/j.childyouth.2009.04.011.

47. Gros D, Gros K, Acienro R, Frueh B, Morland L. Relation between treatment satisfaction and treatment outcome in veterans with posttraumatic stress disorder. *J Psychopathol Behav Assess*. 2013;35(4):522–530. doi:10.1007/s10862-013-9361-6.

48. Hansson EE, Beckman A, Wihlborg A, Persson S, Troein M. Satisfaction with rehabilitation in relation to self-perceived quality of life and function among patients with stroke - a 12 month follow-up. *Scand J Caring Sci*. 2013;27(2):373–379. doi:10.1111/j.1471-6712.2012.01041.x.

49. Taub E, Uswatte G, King D, Morris D, Crago J, Chatterjee A. A placebo-controlled trial of Constraint-Induced Movement therapy for upper extremity after stroke. *Stroke*. 2006;37(4):1045–1049. doi:10.1161/01.STR.0000206463.66461.97.

50. Kelly KM, Borstad AL, Kline D, Gauthier LV. Improved quality of life following Constraint-Induced Movement therapy is associated with gains in arm use, but not motor improvement. *Top Stroke Rehabil*. 2018;25(7):467–474. doi:10.1080/10749357.2018.1481605.