Published in final edited form as:

Am J Occup Ther. 2010 ; 64(6): 929–934.

The Timing of Mentally Versus Physically Practiced Affected Arm Movements in Stroke

Andy Wu, BS, OT¹[Student in the Department of Occupational Therapy Education]

¹The University of Kansas Medical Center, Kansas City, KS

Valerie Hermann, MS, OTR/L²[Occupational Therapy Research Assistant in the Department of Rehabilitation Sciences]

²The University of Cincinnati Academic Medical Center (UCAMC), Cincinnati, OH

Jun Ying, Ph.D.³[Biostatistician]

³The Institute for the Study of Health, UCAMC

Stephen J. Page, Ph.D.⁴[Associate Professor in the Departments of Rehabilitation Sciences, Physical Medicine and Rehabilitation, and Neurosciences, and a Scholar, Director of the Neuromotor Recovery and Rehabilitation Laboratory (NMRRL)]

⁴The Institute for the Study of Health, all at UCAMC, Drake Center, Cincinnati, OH

Abstract

Objective—Mental practice has been suggested as an adjunctive therapy to physical practice in stroke, but ensuring actual engagement is one of the challenges clinical settings may encounter. The purpose of this study is to determine whether chronometry is appropriate for monitoring engagement in mental practice by comparing the time taken for individuals with chronic stroke to mentally and physically practice 5 tasks.

Method—Eighteen stroke participants were allotted 120 seconds to rehearse each task: reaching for and grasping a cup, turning a page in book, comb hair, writing, and eating with a spoon. The participants mentally and physically practiced tasks 3 times with each arm. Time to complete tasks was recorded for each of the 3 trials per task.

Results—Statistical analyses revealed that participants required significantly less time to mentally practice versus physically practice tasks, especially among patients with hemorrhagic stroke ($p < 0.05$).

Conclusions—Since there was not agreement between the time taken to mentally and physically practice the tasks, chronometry does not appear to be valid for monitoring mental practice use in this population. However, participants appear to validly represent deficits in the more-affected versus less-affected arms during mental practice, although the extent of motor deficit may be underestimated.

Mental practice (MP) is a non-invasive technique in which physical tasks and/or scenarios are cognitively rehearsed, usually without voluntary physical movements. The same musculature is activated during MP as during physical practice of the same task (Bakker, Boschker, & Chung, 1996; Hale, 1982; Livesay & Samaras, 1998; Mellet, Petit, Mazoyer, Denis, & Tzourio, 1998). Neuroimaging studies have also revealed that identical neural structures subserve physical and imagined movements (Lacourse, Turner, Randolph-Orr,

Schandler, & Cohen, 2004; Lafleur et al., 2002; Mellet et al., 1998). Because muscular and neural activations are observed during MP, repeated MP use can allow for a practice effect to occur. Consequently, MP has been effectively applied as an adjunct practice strategy to physical practice in exercise and sport settings (for a review, see (Martin, Moritz, & Hall, 1999)), and in a variety of rehabilitative settings (Fairweather & Sidaway, 1993; Fansler, Poff, & Shepard, 1985; Linden, Uhley, Smith, & Bush, 1989; Sidaway & Trzaska, 2005; Williams, Odley, & Callaghan, 2004).

MP has also been used as an adjunctive strategy to physical practice after stroke. Its addition to physical practice causes increased affected arm use (Page, Levine, & Leonard, 2005), kinematics (Hewett, Ford, Levine, & Page, 2007), and function in stroke patients (Crosbie, McDonough, Gilmore, & Wiggam, 2004; Dijkerman, Ietswaart, Johnston, & MacWalter, 2004; Page, 2000; S. J. Page, P. Levine, S. Sisto, & M. Johnston, 2001a; S. J. Page, P. Levine, S. Sisto, & M. V. Johnston, 2001b), including a recent, randomized controlled trial (Page, Levine, & Leonard, 2007). However, a barrier to MP clinical implementation is assurance that patients are actually engaged in MP of the intended activities. Neuroimaging (Lacourse et al., 2004) and autonomic monitoring (Guillot & Collet, 2005a) offer scientifically validated solutions to this challenge, but are implausible in most clinical environments.

An easily implemented method of monitoring MP engagement is mental chronometry, in which the time taken to plan for and execute movements is determined. Specifically, the length of time to imagine a movement is compared to the time taken to physically perform the same movement. Constraints such as task complexity and time can alter the duration of mental imagery, leading to under- or overestimation. Given that durations of highly automatic movements are comparable in healthy participants (Papaxanthis, Pozzo, Skoura, & Schieppati, 2002; Papaxanthis, Schieppati, Gentili, & Pozzo, 2002), and that the speed accuracy tradeoff (i.e., Fitt's Law) is maintained during MP (Decety & Jeannerod, 1995), chronometry presents a plausible monitoring strategy in clinical situations with people who have had a stroke. Studies enrolling nondisabled participants have shown that participants take similar amounts of time to mentally practice movements as is taken to physically perform the same movements (Decety, Jeannerod, & Prablanc, 1989). Mental chronometry has also been applied to stroke, but the small number of patients limits potential inferences (Malouin, Richards, Desrosiers, & Doyon, 2004; Sirigu et al., 1995; Sirigu et al., 1996). The current study examined whether this effect also holds true for participants with stroke, who are mentally and physically practicing movements with their arms.

To our knowledge, MP chronometry has not been applied to examine the timing of imagined versus actual arm movements in people with stroke. This study determined the degree of agreement between times taken for people with chronic stroke to mentally and physically practice a set of 5 tasks. We proposed 3 hypotheses in this paper: (1) Participants would take less time to complete tasks (we call it "time taken" [in seconds] for convenience) in the MP trial; (2) participants would be more likely to succeed in completing the tasks in the MP trial; and (3) the efficacy (in terms of time taken) of MP intervention might be varied by different types of stroke.

Methods

A cross sectional study design was employed in order to investigate the association between mentally and physically practiced tasks in individuals with stroke.

Participant Selection

Participants were recruited using advertisements placed in therapy clinics, and given to therapists. A research team member screened volunteers using the following *inclusion criteria*, which were based on previous studies (Crosbie et al., 2004; Dijkerman et al., 2004; Page, 2000; Page et al., 2001a; Page et al., 2001b): (1) $\geq 10^\circ$ of active flexion in the more-affected wrist, as well as 2 digits in the more-affected hand; (2) stroke experienced > 12 months prior to study enrollment; (3) score ≥ 25 on the Mini Mental Status Examination (MMSE) to assure adequate cognitive processing in order to complete tasks, (4) age $> 18 < 95$; (5) discharged from all forms of physical rehabilitation. *Exclusion criteria* were: (1) excessive spasticity in the more-affected upper limb, as defined as a score of ≥ 3 on the Modified Ashworth Spasticity Scale (Bohannon & Smith, 1987); (2) excessive pain in the more-affected upper limb, as measured by a score ≥ 5 on a 10-point visual analog scale; (3) experienced > 1 stroke; (4) history of a parietal stroke (because some data (Sirigu et al., 1996) suggest that ability to estimate manual motor performance through mental imagery is disturbed after parietal lobe damage); (5) still participating in any experimental rehabilitation or drug studies; and (6) sensory or visuo-spatial deficits, as determined by neurologic exam.

Instruments

To gauge participants' affected arm impairment, we administered the upper extremity section of the *Fugl-Meyer Scale (FM)* (Fugl-Meyer, Jaasko, Leyman, Olsson, & Steglind, 1975) just prior to the below described procedures. FM data arise from a 3-point ordinal scale (0=cannot perform; 1=performs partially; 2=performs fully) applied to each item, and the items are summed to provide a maximum score of 66. The FM has been shown to have impressive test-retest reliability (total=.98-.99; subtests=.87-1.00), interrater reliability, and construct validity (Di Fabio & Badke, 1990; Duncan et al., 1997). It has also been used as an outcome measure in a number of MP trials (Crosbie et al., 2004; Dijkerman et al., 2004; Page, 2000; Page et al., 2007; Page et al., 2001a; Page et al., 2001b), prompting our decision to use it as a baseline measure of motor impairment in the current study.

Procedures

MP is more efficacious when participants rehearse movements with which they have previous experience (Mulder, Zijlstra, Zijlstra, & Hochstenbach, 2004; Mutsaerts, Steenbergen, & Bekkering, 2006). To control for prior experience, all participants had received identical amounts and sequencing of the following 5 tasks, as part of their participation in physical and mental practice trials: reaching for and grasping a cup, turning a page in a book, using a hairbrush or comb, proper use of a writing utensil, and proper use of an eating utensil. As part of that trial, participants had been scheduled to return to this laboratory 6 months after completing the trial's intervention phase. Procedures for the current sub-study had been included in the consenting process for the MP trial and all participants gave informed consent in concordance with the local Institutional Review Board.

Physical practice trial (PP trial)—Upon arriving at the laboratory, each participant was escorted to a quiet room and seated at a table, where a research assistant reminded him/her of procedures for this chronometry study. Participants were then re-oriented to the abovementioned tasks (≈ 5 minutes), consisting of laying out the objects used during each movement, and reminding the participant how he/she physically rehearsed its use during the study. Each task was presented approximately 15.2 centimeters from the edge of the table and involved predetermined components. For example, reaching for a cup: reaching for the handle, grasping the handle, and then bringing it towards the mouth.

On the command, “ready, go,” participants physically attempted each task 3 times, first with the less-affected arm and then with the more-affected arm. One-minute rest breaks were provided after each of these attempts; a 3-minute rest break was provided between the last attempt of one task and the first attempt of the next new task in sequence. The research assistant recorded each timed trial in seconds (to the hundredths), using a standard stopwatch. The participants were allotted 120 seconds to complete each trial. After attempting all of the physical tasks 3 times with each arm, each participant was provided with a 10-minute rest break.

Mental practice trial (MP trial)—Following the break, each participant was again seated at the table. The participants were then reminded of the practice in which they had engaged during the MP trial, reminded of the current chronometry trial objectives, and told that they were now going to mentally rehearse each task. The sequencing and duration of the mental practice attempts and rest breaks were the same as for the physical practice: all of the tasks were cognitively rehearsed three times, with each arm. Participants were instructed to mentally rehearse tasks in their current physical status. Again, upon the “ready, go” command, participants mentally attempted each movement 3 times. The participants were instructed to indicate completion of the cognitive rehearsal with a verbal “done” or by raising their less-affected arm. The research assistant recorded each timed trial, as with the physical practice, upon the participant's notion of completion.

We decided that all participants would first physically perform the tasks, and then mentally perform them because this ordering mimicked how physical and mental practice were presented in participants' previous experiences. That is, during the trial in which they had participated, participants underwent occupational therapy of the tasks above; then, after a short rest break, participants mentally rehearsed the tasks.

All data were maintained in accordance with the local Institutional Review Board. Each participant's files were de-identified and separated from their consent forms. Files were stored in a locked filing cabinet and only approved study personnel were granted access.

Data Analyses

Numerical variables were summarized using means $\pm$ standard error (SE), and/or medians (ranges); categorical variables were summarized by frequency in percent. The primary analysis was to assess the association of time taken (or time to complete a task, in seconds) on the more-affected arm only (PP and MP trials), under consideration of stroke types (ischemic and hemorrhagic stroke) and tasks. Hence, a mixed effect model was applied in the analysis using the numerical variable of time taken as the dependent variable, the trial and its interactions to the stroke type and the task as major fixed effects of interest, and patient's demographics and impairment levels (FM) as controlling covariates. A random effect (i.e., the participants) was introduced in the model to account for within participant correlation caused by repeated observations of two trials. *Post hoc* comparisons of means of time taken between trials were performed for each stroke type and each task under the mixed effect model framework. Bonferroni's methods were used to adjust for overall type I error when multiple comparisons of means were involved. In the secondary analysis, a similar mixed effect model was used to compare time taken between more-affected and less-affected arms in the MP trial. The fixed effect of interest was the arm (more-affected and less-affected arms) and its interaction with the task. Finally, in order to compare the rates of successfully completing a task between PP and MP, a McNemar's test was used in each task on the the more-affected arm only. All analyses were performed using SAS 9.1 software (SAS, Cary, NC). P-values < 0.05 were considered statistically significant.

Results

Using the aforementioned criteria, 18 individuals were included (7 females; median (range) of age = 61.5 (35, 74) years; median (range) time since stroke = 50.0 (15, 215) months). Participant demographics and baseline information are provided in Table 1.

Means of time taken using the more-affected arm to complete tasks are summarized in Table 2. For this analysis, obtaining significant p-values (< 0.01) do not support our primary hypothesis of highly similar times between the PP and MP trials. For all participants, the averages of time taken during the PP trial were 7.5–11.3 seconds to complete the tasks. They were 3.8–7.1 seconds during the MP trial, significantly shorter than the PP trial (p 's < 0.01). While patients with hemorrhagic stroke took longer to complete tasks in the PP trial, they showed significant reductions in time for tasks 3–5 during the MP trial (p 's ≤ 0.01). In contrast, individuals with ischemic stroke did not show differences between times required to mentally and physically practice 4 of the five tasks

When comparing more-affected and less-affected arms in the MP trial, we found a significantly greater amount of time was taken to mentally rehearse each of the tasks with the more-affected arm versus the less-affected arm (Table 3). The averages of time taken were 3.7–7.2 seconds in the more-affected arms, compared to 1.7–1.9 seconds in the less-affected arms (p 's < 0.01).

In the PP trial, only 8 participants (44%) completed all tasks successfully. The MP trial showed an 89% completion rate, which is much improved from the PP trial ($p < 0.01$). When looking at each task individually, tasks 1, 2, and 5 were the least “difficult” with completion rates $\geq 94\%$ in both trials (MP and PP). Demonstrating proper use of a writing utensil was, however, the most “difficult” in the PP trial with a completion rate of 50%. It was observed to be 89% in the MP trial ($p < 0.01$) (Table 4).

Discussion

Based on the results obtained in this study, participants required a significantly larger amount of time to physically practice the tasks than they required to mentally rehearse the same tasks. This finding did not confirm the primary study hypothesis. Since no study has examined this phenomenon for tasks involving the more-affected arm, no standard of comparison is available. However, one possible explanation for this outcome is that this study involved a series of complex, multi-step tasks; tasks requiring a significant degree of coordination, precision, and timing of the more-affected arm.

The complexity of tasks in this study required a higher level of function from participants. As such, to physically complete such tasks would take greater effort and time, whereas mentally rehearsing tasks may take less. While numerous studies have demonstrated that mental durations increase as task difficulty increases (Decety et al., 1989; Decety & Lindgren, 1991; Jeannerod, 1995, 1999), a review of mental durations found that when the task is perceived as easy to perform, the duration of mental imagery may be shorter than the duration of actual performance (Guillot & Collet, 2005b). This same review also notes that, in healthy individuals, time taken was similar in cyclic, highly automatic. In fact, in a recent study published on mental chronometry, the stepping task was relatively easy and the authors suggest that temporal congruence, between imagined and executed tasks, remained intact after stroke (Malouin, Richards, Durand, & Doyon, 2008). Conversely, participants in the present study were required to perform more complex tasks that were neither cyclic nor automatic in nature; however, did not demonstrate longer mental duration times, but shorter. Thus, the combination of tasks in this study, along with perception of task difficulty, may

attribute to the primary finding of a significant discrepancy between time taken to physically versus mentally practiced tasks.

We observed that participants who experienced an ischemic stroke performed both mental and physical tasks faster than those who had hemorrhagic strokes. Ischemic stroke damage is typically more localized and isolated. The fact that participants with ischemic stroke demonstrated no difference in times on 4 of the 5 tasks suggested that their ischemic strokes spared portions of the parietal lobe responsible for estimating temporal aspects of motor performance. This was verified when we examined their CT scans. The contrary is true of people with hemorrhagic strokes, which often result in more diffuse damage with non-specific borders. This finding has definite implications when considering possible candidates for MP: individuals with ischemic stroke may stand to benefit greater from MP, as timing is a crucial component in movement.

We also hypothesized that participants would expend more time mentally practicing tasks with their more-affected arms than mentally practicing the same tasks with their less-affected arms. This hypothesis was supported; every mentally rehearsed movement using the more-affected arm took significantly longer to complete ($p < 0.01$). This finding suggests that stroke participants who are mentally practicing create an accurate mental depiction of their arms as exhibiting motor deficits. However, data in Table 3 also suggest that these participants may underestimate their severity of deficit in their more-affected arm during MP. Indeed, during MP, we found that participants often over-estimated the speed with which they could complete tasks that they could not physically complete.

Taken together, these findings suggest that clinicians can expect patients to recognize that they have arm motor deficits during MP; however, their mental depictions of these tasks may not accurately portray the extent of their motor deficits, and/or their ability to perform these tasks. MP audiotapes, thus, need to explicitly encourage patients to attend to how far and how well they are moving their arms in relation to actual movement abilities. Clinicians may also want to carefully review patients' motor abilities with them before patients initiate MP, so that the mental skill depictions accurately reflect the timing of movements. Higher completion rates observed during MP are promising, as MP can provide safe, repetitive practice in the absence of a therapist. While this may be true, using chronometry to monitor actual engagement in mental practice in stroke participants may not be warranted as temporal characteristics of movements appears to be disrupted after stroke.

Limitations

There were two, primary study limitations. First, due to time constraints, the number of participants was relatively small. However, we expect to overcome this limitation with larger MP studies, which are currently underway. Secondly, the participants practiced each task on only 3 occasions, whereas, in other chronometry studies, the number of practice trials has been significantly higher. However, such studies also involved healthy individuals who were capable of performing such tasks with little difficulty, while patients with stroke may experience greater movement difficulty, fatigue, and frustration. Despite the above study limitations, we suspect that the herein described findings are valid, and have important implications for MP implementation in clinical practice.

References

- Bakker FC, Boschker MS, Chung T. Changes in muscular activity while imagining weight lifting using stimulus or response propositions. *Journal of Sport Exercise Physiology*. 1996; 18(3):313–324.

- Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther.* 1987; 67(2):206–207. [PubMed: 3809245]
- Crosbie JH, McDonough SM, Gilmore DH, Wiggam MI. The adjunctive role of mental practice in the rehabilitation of the upper limb after hemiplegic stroke: a pilot study. *Clin Rehabil.* 2004; 18(1):60–68. [PubMed: 14763720]
- Decety J, Jeannerod M. Mentally simulated movements in virtual reality: does Fitts's law hold in motor imagery? *Behav Brain Res.* 1995; 72(1–2):127–134. [PubMed: 8788865]
- Decety J, Jeannerod M, Prablanc C. The timing of mentally represented actions. *Behav Brain Res.* 1989; 34(1–2):35–42. [PubMed: 2765170]
- Decety J, Lindgren M. Sensation of effort and duration of mentally executed actions. *Scand J Psychol.* 1991; 32(2):97–104. [PubMed: 2068552]
- Di Fabio RP, Badke MB. Relationship of sensory organization to balance function in patients with hemiplegia. *Phys Ther.* 1990; 70(9):542–548. [PubMed: 2392483]
- Dijkerman HC, Ietswaart M, Johnston M, MacWalter RS. Does motor imagery training improve hand function in chronic stroke patients? A pilot study. *Clin Rehabil.* 2004; 18(5):538–549. [PubMed: 15293488]
- Duncan PW, Samsa GP, Weinberger M, Goldstein LB, Bonito A, Witter DM, et al. Health status of individuals with mild stroke. *Stroke.* 1997; 28(4):740–745. [PubMed: 9099189]
- Fairweather MM, Sidaway B. Ideokinetic imagery as a postural development technique. *Res Q Exerc Sport.* 1993; 64(4):385–392. [PubMed: 8278664]
- Fansler CL, Poff CL, Shepard KF. Effects of mental practice on balance in elderly women. *Phys Ther.* 1985; 65(9):1332–1338. [PubMed: 4034667]
- Fugl-Meyer AR, Jaasko L, Leyman I, Olsson S, Steglind S. The post-stroke hemiplegic patient. 1. a method for evaluation of physical performance. *Scand J Rehabil Med.* 1975; 7(1):13–31. [PubMed: 1135616]
- Guillot A, Collet C. Contribution from neurophysiological and psychological methods to the study of motor imagery. *Brain Res Brain Res Rev.* 2005a; 50(2):387–397. [PubMed: 16271398]
- Guillot A, Collet C. Duration of mentally simulated movement: a review. *J Mot Behav.* 2005b; 37(1):10–20. [PubMed: 15642689]
- Hale BD. The effects of internal and external imagery on muscular and ocular concomitants. *Journal of Sport Exercise Physiology.* 1982; 4(4):379–387.
- Hewett TE, Ford KR, Levine P, Page SJ. Reaching kinematics to measure motor changes after mental practice in stroke. *Top Stroke Rehabil.* 2007; 14(4):23–29. [PubMed: 17698455]
- Jeannerod M. Mental imagery in the motor context. *Neuropsychologia.* 1995; 33(11):1419–1432. [PubMed: 8584178]
- Jeannerod M. The 25th Bartlett Lecture. To act or not to act: perspectives on the representation of actions. *Q J Exp Psychol A.* 1999; 52(1):1–29. [PubMed: 10101973]
- Lacourse MG, Turner JA, Randolph-Orr E, Schandler SL, Cohen MJ. Cerebral and cerebellar sensorimotor plasticity following motor imagery-based mental practice of a sequential movement. *J Rehabil Res Dev.* 2004; 41(4):505–524. [PubMed: 15558380]
- Lafleur MF, Jackson PL, Malouin F, Richards CL, Evans AC, Doyon J. Motor learning produces parallel dynamic functional changes during the execution and imagination of sequential foot movements. *Neuroimage.* 2002; 16(1):142–157. [PubMed: 11969325]
- Linden CA, Uhley JE, Smith D, Bush MA. The effects of mental practice on walking balance in an elderly population. *Occup Ther J Res.* 1989; 9(3):155–169.
- Livesay JR, Samaras MR. Covert neuromuscular activity of the dominant forearm during visualization of a motor task. *Percept Mot Skills.* 1998; 86(2):371–374. [PubMed: 10049098]
- Malouin F, Richards CL, Desrosiers J, Doyon J. Bilateral slowing of mentally simulated actions after stroke. *Neuroreport.* 2004; 15(8):1349–1353. [PubMed: 15167564]
- Malouin F, Richards CL, Durand A, Doyon J. Reliability of mental chronometry for assessing motor imagery ability after stroke. *Arch Phys Med Rehabil.* 2008; 89(2):311–319. [PubMed: 18226656]
- Martin KA, Moritz SE, Hall CR. Imagery use in sport: A literature review and applied model. *The Sport Psychologist.* 1999; 13(3):245–268.

- Mellet E, Petit L, Mazoyer B, Denis M, Tzourio N. Reopening the mental imagery debate: lessons from functional anatomy. *Neuroimage*. 1998; 8(2):129–139. [PubMed: 9740756]
- Mulder T, Zijlstra S, Zijlstra W, Hochstenbach J. The role of motor imagery in learning a totally novel movement. *Exp Brain Res*. 2004; 154(2):211–217. [PubMed: 14508635]
- Mutsaerts M, Steenbergen B, Bekkering H. Anticipatory planning deficits and task context effects in hemiparetic cerebral palsy. *Exp Brain Res*. 2006; 172(2):151–162. [PubMed: 16538378]
- Page SJ. Imagery improves upper extremity motor functions in chronic stroke patients with hemiplegia: a pilot study. *Occup Ther J Res*. 2000; 20(3):200–215.
- Page SJ, Levine P, Leonard A. Mental practice in chronic stroke: results of a randomized, placebo-controlled trial. *Stroke*. 2007; 38(4):1293–1297. [PubMed: 17332444]
- Page SJ, Levine P, Leonard AC. Effects of mental practice on affected limb use and function in chronic stroke. *Arch Phys Med Rehabil*. 2005; 86(3):399–402. [PubMed: 15759218]
- Page SJ, Levine P, Sisto S, Johnston M. Imagery combined with physical practice for upper limb motor deficit in sub-acute stroke: A case report. *Phys Ther*. 2001a; 81(8):1455–1462. [PubMed: 11509075]
- Page SJ, Levine P, Sisto S, Johnston MV. A randomized efficacy and feasibility study of imagery in acute stroke. *Clin Rehabil*. 2001b; 15(3):233–240. [PubMed: 11386392]
- Papaxanthis C, Pozzo T, Skoura X, Schieppati M. Does order and timing in performance of imagined and actual movements affect the motor imagery process? The duration of walking and writing task. *Behav Brain Res*. 2002; 134(1–2):209–215. [PubMed: 12191807]
- Papaxanthis C, Schieppati M, Gentili R, Pozzo T. Imagined and actual arm movements have similar durations when performed under different conditions of direction and mass. *Exp Brain Res*. 2002; 143(4):447–452. [PubMed: 11914790]
- Sidaway B, Trzaska AR. Can mental practice increase ankle dorsiflexor torque? *Phys Ther*. 2005; 85(10):1053–1060. [PubMed: 16180954]
- Sirigu A, Cohen L, Duhamel JR, Pillon B, Dubois B, Agid Y, et al. Congruent unilateral impairments for real and imagined hand movements. *Neuroreport*. 1995; 6(7):997–1001. [PubMed: 7632907]
- Sirigu A, Duhamel JR, Cohen L, Pillon B, Dubois B, Agid Y. The mental representation of hand movements after parietal cortex damage. *Science*. 1996; 273(5281):1564–1568. [PubMed: 8703221]
- Williams JG, Odley JL, Callaghan M. Motor imagery boosts proprioceptive neuromuscular facilitation in attainment and retention of range-of-motion at the hip joint. *Journal of Sports Science and Medicine*. 2004; 3(3):160–166.

Table 1

Summary of demographic information

Variable	Category	Descriptive Statistics (n=18) [†]
<i>Demographics</i>		
Age		59.1 ± 2.7 & 61.5 (35, 74)
Gender	female	38.9% (7/18)
<i>CVA / UE[‡]</i>		
Duration of CVA (months)		69.5 ± 12.0 & 50.0 (15, 212)
Type of CVA (hemorrhagic vs. ischemic)	hemorrhagic	40.0% (6/15) [*]
Side of CVA (left vs. right)	left	44.4% (8/18)
UE Sensation (impaired vs. intact)	impaired	33.3% (6/18)
<i>FuglMyer Scale</i>		
Total		31.1 ± 2.2 & 30.5 (17, 53)
Wrist/Hand		8.5 ± 1.1 & 8.0 (1, 19)
	>5	27.8% (5/18)

Note.

[†] Values are mean + standard error (SE) & median (range) for numerical variables and frequency in % (count / total) for binary variables.

[‡] CVA = Cerebral vascular accident; and UE = Upper extremity.

^{*} n=15 (3 participants were unable to report type of stroke).

Table 2

Comparison of time taken to mentally and physically practice each task with the more-affected arm

Task	Categories	MP [†]	PP [‡]	p-value [‡]
1. Reaching for and grasping a cup	All	5.7 ± 1.5	10.2 ± 1.5	0.03
	Type of CVA			
	hemorrhagic ischemic	9.6 ± 2.5 2.7 ± 2.2	15.2 ± 2.5 6.6 ± 2.2	0.12 0.18
2. Turning pages in a book	All	7.1 ± 1.5	11.3 ± 1.6	0.05
	Type of CVA			
	hemorrhagic ischemic	12.9 ± 2.3 1.7 ± 2.0	11.1 ± 2.6 8.7 ± 2.0	0.60 0.01
3. Using a hairbrush or comb	All	3.9 ± 0.9	7.5 ± 1.0	0.01
	Type of CVA			
	hemorrhagic ischemic	4.5 ± 1.5 3.8 ± 1.1	10.3 ± 1.9 4.8 ± 1.2	0.01 0.50
4. Proper use of a writing utensil	All	4.7 ± 1.0	9.4 ± 1.3	0.01
	Type of CVA			
	hemorrhagic ischemic	5.8 ± 1.7 3.1 ± 1.3	15.5 ± 2.0 5.0 ± 1.6	<0.01 0.36
5. Proper use of an eating utensil	All	3.8 ± 1.0	7.8 ± 1.0	<0.01
	Type of CVA			
	hemorrhagic ischemic	3.7 ± 2.0 3.1 ± 1.5	11.3 ± 1.8 4.9 ± 1.5	<0.01 0.38

Note. "MP" denotes "mental practice; "PP" denotes "physical practice.

[†] Values are mean + standard error (SE).

[‡] p-values are from mixed effect models, adjusting for age and gender of patients.

Table 3

Comparison of time taken to mentally practice each task with the more-affected arm versus the less-affected arm

Task	More-affected [†]	Less-affected [†]	p-value [‡]
1. Reaching for and grasping a cup	5.8 ± 0.6	1.9 ± 0.7	< 0.01
2. Turning pages in a book	7.2 ± 1.2	1.5 ± 1.3	< 0.01
3. Using a hairbrush or comb	4.1 ± 0.3	1.9 ± 0.3	< 0.01
4. Proper use of a writing utensil	4.8 ± 0.4	1.9 ± 0.4	< 0.01
5. Proper use of an eating utensil	3.7 ± 0.2	1.9 ± 0.3	< 0.01

Note.

[†]Values are mean + standard error (SE).

[‡]p-values are from mixed effect models, adjusting for age and gender of patients.

Table 4

Percent of task completion during mental and physical practice of each task during the MP trial

Task	Mental Practice [†]	Physical Practice [†]
1. Reaching for and grasping a cup	100% (18)	100% (18)
2. Turning pages in a book	100% (18)	94% (17)
3. Using a hairbrush or comb	89% (16)	72% (13)
4. Proper use of a writing utensil	89% (16) [*]	50% (9)
5. Proper use of an eating utensil	94% (17)	100% (18)
All tasks	89% (16) [*]	44% (8)

Note.[†] Values are percent (number of participants to complete task)^{*} indicates % of completion is higher using MP than using PP, with $p < 0.01$ from a McNemar's test.