Objective: This preliminary study sought to determine whether the imagery perspective used during mental practice (MP) differentially influenced performance outcomes after stroke.

Method: Nineteen participants with unilateral subacute stroke (9 men and 10 women, ages 28–77) were randomly allocated to one of three groups. All groups received 30-min occupational therapy sessions 2×/wk for 6 wk. Experimental groups received MP training in functional tasks using either an internal or an external perspective; the control group received relaxation imagery training. Participants were pre- and posttested using the Fugl–Meyer Motor Assessment (FMA), the Jebsen–Taylor Test of Hand Function (JTTHF), and the Canadian Occupational Performance Measure (COPM).

Results: At posttest, the internal and external experimental groups showed statistically similar improvements on the FMA and JTTHF (p < .05). All groups improved on the COPM (p < .05).

Conclusion: MP combined with occupational therapy improves upper-extremity recovery after stroke. MP does not appear to enhance self-perception of performance. This preliminary study suggests that imagery perspective may not be an important variable in MP interventions.
using an internal perspective, clients imagine performing the movements from the perspective of being inside their body; thus, they imagine looking out through their own eyes when performing the movements. When using an external perspective, clients imagine performing the movements from the perspective of being outside their body; thus, they imagine being an observer of themselves in motion (Spittle & Morris, 2007). Interestingly, an examination of the MP poststroke literature reveals differences in instruction regarding imagery perspective (Nilsen et al., 2010), with studies instructing participants to use an internal perspective (e.g., Page, Levine, & Leonard, 2007), external perspective (e.g., Page, 2000), or combination of the two (e.g., Dunskey, Dickstein, Marcovitz, Levy, & Deutsch, 2008). Because perspective switching is a phenomenon known to occur (Gordon, Weinberg, & Jackson, 1994), it is important to monitor whether clients hold the perspective they are instructed to use (Spittle & Morris, 2007). Unfortunately, this point has been largely neglected in the MP poststroke literature.

Despite inconsistency in instruction for imagery perspective and monitoring of perspective use, some researchers have suggested that motor imagery from a first-person perspective is an essential part of MP for neurological rehabilitation because it is thought to most closely resemble physical practice (Jackson et al., 2001; Malouin & Richards, 2010). Perhaps the greatest support for this position comes from studies investigating the neural correlates of imagined and executed actions. Studies that compared imagined movements generated from the first- and third-person perspectives revealed greater activation in the neural structures associated with sensorimotor activity when imagery was performed from the first-person perspective (Lorey et al., 2009; Solodkin, Hlustik, Chen, & Small, 2004). Given these similarities, it is conceivable that MP performed from an internal point of view would be optimal. To date, however, this hypothesis has not been empirically tested in people after stroke, and behavioral studies investigating perspective use during MP in healthy people have revealed that both perspectives can improve motor performance (Hardy & Callow, 1999; Weigardt, 1997).

Additionally, some researchers have suggested that external imagery may enhance motivation (Vasquez & Buehler, 2007) and self-perception and thereby affect subsequent behavior (Libby, Shaeffer, Eibach, & Slemmer, 2007) to a greater extent than imagery from an internal point of view. Hence, the question of which perspective is most beneficial for poststroke rehabilitation is open to debate.

We conducted a preliminary study to determine whether the perspective used during MP differentially influences outcomes poststroke. Given that imagery from an internal perspective activates neural networks more closely related to those activated during actual action, we anticipated that MP using an internal perspective would be more effective in reducing impairments and improving function. However, given that imagery generated from an external perspective appears to enhance self-perception and motivation to a greater extent, we anticipated that MP using an external view would be preferential for enhancing self-perception of occupational performance. Specifically, we sought to determine the following:

1. Whether occupational therapy combined with MP from either perspective would reduce impairment, improve function, and enhance self-perception of performance above a control condition;
2. Whether MP using an internal perspective would be more effective in reducing impairment and improving function than MP using an external perspective; and
3. Whether MP using an external perspective would be more effective in enhancing self-perception of occupational performance than MP using an internal perspective.

Method

Research Design

We conducted a single-blind, randomized controlled trial over an 18-mo period; participants were enrolled and received the intervention on an ongoing basis. After they had provided informed consent, 19 participants were randomly assigned to one of three groups using concealed allocation (see Figure 1): (1) occupational therapy + MP from the internal perspective (internal group), (2) occupational therapy + MP from the external perspective (external group), and (3) occupational therapy + relaxation imagery (control group). The Institutional review boards of Teachers College, Columbia University, and Orange Regional Medical Center approved the study.

Participants

We recruited participants from New York City and surrounding areas by means of flyers, contact with stroke support groups, and use of a stroke registry. After initial telephone contact, we screened 30 people who had clinical evidence of a single unilateral stroke (minimum 9 wk postonset) and who were between the ages of 18 and 90 yr. To be included, potential participants had to be cognitively intact, defined as ≥60 on the modified Mini-Mental State Exam (Teng & Chui, 1987), and able to actively flex the affected wrist and metacarpophalangeal and
interphalangeal joints of two digits of the hand a minimum of 10° from neutral. Potential participants were excluded if they had excessive pain (≥4 on a visual analog scale; Adams, n.d.) or spasticity (≥3 on the Modified Ashworth Spasticity Scale; Bohannon & Smith, 1987), were unable to perform imagery (>36 on either the internal or external visual imagery subscales of the Vividness of Movement Imagery Questionnaire–2 [VMIQ–2]; Roberts, Callow, Hardy, Markland, & Bringer, 2008), were too low functioning (surpassing a total time of 1,080 s on the Jebsen–Taylor Test of Hand Function [JTTHF]; Jebson, Taylor, Trieschmann, Trotter, & Howard, 1969), were too high functioning (<40% discrepancy between the hands on the JTTHF), or were undergoing therapy to improve arm or hand function (or both).

**Instruments and Outcome Measures**

To determine imagery ability, we administered the VMIQ–2. This questionnaire evaluates a person’s imagery ability from both the internal and the external visual imagery perspectives and using the kinesthetic imagery modality, and it has concurrent and construct validity (Roberts et al., 2008). For each subsection, people imagine themselves performing 12 movements (e.g., walking, throwing a stone), and they rate the clarity and vividness of the image using a 5-point scale. Scores for each subsection range from 12 to 60, and lower scores indicate more vivid images.

To assess changes at various levels of analysis, we administered three outcome measures:

1. **Primary measure 1:** The UE section of the Fugl-Meyer Assessment of Motor Recovery (FMA; Fugl-Meyer, Jääskö, Leyman, Olsson, & Stegland, 1975) evaluates impairment using a 3-point ordinal scale (maximum score = 66 points; higher scores indicate less impairment). The FMA has high test–retest reliability (r = .99), interrater reliability (rs = .96–.97; Duncan, Propst, & Nelson, 1983), and construct validity (see Malouin, Pichard, Bonneau, Durand, & Corriveau, 1994).

2. **Primary measure 2:** The JTTHF evaluates hand function, and it has been shown to have strong test–retest reliability (rs = .67–.99; Jebson et al., 1969; Stern, 1992) and validity in predicting functional hand function.
use in ADLs (Lynch & Bridle, 1989). The durations of six of the seven subtests (the writing subtest was removed) were summed to generate a total time score; faster times indicate greater hand function.

3. Secondary measure: The Canadian Occupational Performance Measure (COPM; Law et al., 1994) evaluates a person’s self-perception of occupational performance and satisfaction with performance using two 10-point ordinal scales. The COPM has been shown to have strong test–retest reliability (intraclass correlation [ICC] = .63 for performance, ICC = .84 for satisfaction; Law et al., 1994), as well as content and concurrent validity (see Carswell et al., 2004). The COPM was modified from its original form in a manner consistent with previous research (see Gillen et al., 2007). Participants were asked to rate five preselected tasks. The five tasks (i.e., drinking from a cup, donning a button-down shirt, folding a towel, brushing teeth, and unpacking groceries) represent common ADLs. Three tasks (i.e., drinking, dressing, and folding) were considered trained, because they were both physically and mentally practiced. Two tasks (i.e., brushing teeth and unpacking groceries) were considered untrained, because they were not physically or mentally practiced.

### Intervention Protocol

Within 3 days before starting the intervention, a trained occupational therapist blinded to group assignment (T. DiRusso) evaluated the participants using the outcome measures. The same evaluator posttested participants within 3 days after they completed the intervention. The evaluator reported that blinding was maintained throughout the study period. Participants received 30-min sessions of occupational therapy 2×/wk for 6 wk. An occupational therapist with experience in the area of neurorehabilitation administered the sessions in either a clinic-based setting (n = 12) or in the participant’s home environment (n = 5). Thus, all participants received treatment by the same therapist. No appreciable differences in participant characteristics were seen between those who received clinic- versus home-based sessions.

The occupational therapy sessions focused on practice of three trained tasks; in the first and second weeks, participants practiced drinking from a cup (involved hand); in the third and fourth weeks, they practiced donning a button-down shirt (both hands); and in the fifth and sixth weeks, they practiced folding a towel (both hands). In addition, participants engaged in a variety of unimanual and bimanual purposeful activities designed to improve arm and hand function. Activities were graded to allow for progression of task complexity and repetition.

The therapist kept treatment logs for each participant to aid in progression of activities and to ensure that the therapist provided the intervention as intended. The therapist encouraged participants to continue with their normal daily routines at home.

Immediately after occupational therapy, participants engaged in a guided MP training session (experimental groups) or a relaxation imagery training session (control group). In the MP training sessions, participants listened to an audiotaped script that facilitated the generation of various imagery modalities (e.g., visual, kinesthetic) designed to simulate the environment in which task performance would take place and the motions that would be generated during overt practice. Scripts were adapted on the basis of the work of previous authors (Dunsky et al., 2008; Gillen, 2007; Page et al., 2007). The trained tasks (drinking from a cup, donning a button-down shirt, folding a towel) were the focus of the MP. The scripts were designed to last the same duration and were divided as follows:

- **Introduction** (approximately 2 min): Description of the task to be imagined and imagery perspective instructions. The internal group was instructed as follows: “You should imagine performing the movements from inside of your body, as if you were looking through your own eyes while performing the movements.” The external group was instructed as follows: “You should imagine watching yourself performing the movements from outside your body, as if you were watching a videotape of yourself on a TV screen.”

- **Relaxation** (approximately 5 min): Suggestions for relaxation of various body parts.

- **Focused imagery** (approximately 8 min): Stimulus and response propositions designed to generate imagery related to the specific task practice and to encourage maintenance of the instructed perspective. Key components of the task were repeated during this section.

- **Refocusing** (approximately 3 min): Instruction to re-focus into the room and instruction regarding use of mental practice, as follows: “Remember not to mentally practice on your own or to speak to anyone about the contents of your practice sessions.”

The control group listened to an audiotaped script focused on relaxation imagery for the same duration. This group was provided no instruction regarding imagery perspective use.

### Determining Perspective Use

On four occasions (Sessions 3, 6, 9, and 12), immediately after the imagery sessions the interventionist conducted a manipulation check on perspective use. Participants were asked to engage in retrospective verbalization and to score
a perspective rating scale to determine which perspective they had used (see Spittle & Morris, 2007). Specifically, they were asked to describe their mental images verbally, and the interventionist transcribed this information. The interventionist then asked participants to rate whether they had engaged in internal or external visual imagery by making a mark on a 10-cm line that was anchored on each end by the words 100% internal and 100% external.

Data Analysis

To determine perspective use, one rater (D. Nilsen) scored the four individual retrospective verbalization transcripts for the percentage of internal and external imagery used according to previously established methods (Spittle & Morris, 2007), and we calculated the mean of the four scores for each participant. We also calculated the mean of the four scores on the rating scale for each participant. Scores ranged from 0 to 100; lower scores indicated more internal imagery use, and higher scores indicated more external imagery use (Spittle & Morris, 2007). A Pearson product–moment correlations was used to evaluate the relationship between the mean retrospective verbalization and mean rating scale scores.

To determine changes in impairment and activity limitation, the results of the FMA and JTTHF were used, respectively. To determine changes in perception of and satisfaction with occupational performance, we used the results of the COPM; specifically, we added the ratings of each of the five tasks on the performance and satisfaction scales to obtain a total performance and satisfaction score. Change scores (posttest — pretest) were calculated for each participant for each measure. From these scores, we calculated a within-group mean change and standard error of the mean (SEM) for each of the measures.

For all measures, we used a 3 (group) × 2 (test) analysis of variance (ANOVA) to assess changes from pretest to posttest. Because assumptions of normality, as assessed by the Shapiro–Wilk test of normality (Shapiro & Wilk, 1965, as cited in Myers & Wells, 2003, p. 185; internal group: pre- and posttest data, p < .03; external group: posttest data, p < .05), and homogeneity of variance, as assessed by Levene’s test of equality of error variance (Levene, 1960, as cited in Myers & Wells, 2003, p. 161; posttest data, p < .02), were violated for the data related to one outcome measure (JTTHF), we transformed the data for all outcome measures using a natural log transformation. Nevertheless, the results of the statistical analysis were qualitatively similar for nontransformed and transformed data for those measures for which assumptions were not violated (FMA and COPM). For all statistical tests, the level of significance was set at p < .05. All data were analyzed using PASW Statistics Version 18 (IBM Inc., Armonk, NY).

Results

Participant Characteristics

Demographics, clinical features, and outcome measures of the groups at baseline are presented in Table 1. The groups were similar in terms of gender, mean time poststroke, and imagery ability, but they differed significantly with respect to age. Post hoc analysis revealed that the internal group was significantly younger than the control group. Although the groups differed with respect to the involved side, with most participants in the internal group having right-side involvement and most participants in the external group having left-side involvement, these differences failed to reach statistical significance. Baseline comparisons showed the groups were not statistically significantly different on any of the outcome measures.

Perspective Maintenance

As anticipated, we found a strong positive relationship between the retrospective verbalization scores and rating scale scores (Figure 2; r = .98, p < .001). More important, most participants instructed to use a given perspective reported using that perspective during MP. For all measures, we used a 3 (group) × 2 (test) analysis of variance (ANOVA) to assess changes from pretest to posttest. Because assumptions of normality, as assessed by the Shapiro–Wilk test of normality (Shapiro & Wilk, 1965, as cited in Myers & Wells, 2003, p. 185; internal group: pre- and posttest data, p < .03; external group: posttest data, p < .05), and homogeneity of variance, as assessed by Levene’s test of equality of error variance (Levene, 1960, as cited in Myers & Wells, 2003, p. 161; posttest data, p < .02), were violated for the data related to one outcome measure (JTTHF), we transformed the data for all outcome measures using a natural log transformation. Nevertheless, the results of the statistical analysis were qualitatively similar for nontransformed and transformed data for those measures for which assumptions were not violated (FMA and COPM). For all statistical tests, the level of significance was set at p < .05. All data were analyzed using PASW Statistics Version 18 (IBM Inc., Armonk, NY).
large effect sizes were seen for both perspectives (internal $d = 1.5$, external $d = 2.0$).

Although the groups did not differ significantly at baseline on the primary outcome measures, the internal group was clearly a higher functioning group. For this reason, we ran an analysis of covariance (ANCOVA) on the posttest scores using the pretest scores as a covariate in addition to the ANOVA. The results of the ANCOVA were consistent with the findings of the ANOVA for both the FMA (main effect of group, $F(2, 12) = 4.454$, $p = .036$) and the JTTHF (main effect of group, $F(2, 12) = 4.454$, $p = .036$). Planned comparisons revealed that the main effect of group in both cases resulted from the experimental groups’ being significantly different from the control group while not being significantly different from each other.

### Secondary Outcome Measure

Regarding self-perception of performance, mean COPM scores increased significantly across all the groups (main effect of test, $F[1, 13] = 47.117$, $p < .001$), resulting in a mean gain of 12.3 ($SEM = 3.86$), 13.2 ($SEM = 3.09$), and 15.6 ($SEM = 3.79$) for the control, internal, and external groups, respectively. Similarly, mean COPM satisfaction scores increased significantly across all the groups (main effect of test, $F[1, 13] = 33.502$, $p < .001$), resulting in a mean gain of 15.3 ($SEM = 3.34$), 12.6 ($SEM = 4.16$), and 16.0 ($SEM = 4.84$) for the control, internal, and external groups, respectively. Moreover, significant increases were seen across the groups, regardless of whether the task was trained or untrained, for both the performance (trained, $F[1, 13] = 46.317$, $p < .001$; untrained, $F[1, 13] = 24.380$, $p < .001$) and satisfaction (trained, $F[1, 13] = 42.742$, $p < .001$; untrained, $F[1, 13] = 19.360$, $p = .001$) scores, respectively.

### Discussion

As anticipated, MP using either the internal or the external imagery perspectives, combined with occupational therapy, reduced impairments and improved function above a control condition. However, MP did not appear to have an additive effect at the self-perception level of analysis. Improvements in self-perception of performance and satisfaction were found for both trained and untrained tasks regardless of group assignment. Moreover, imagery perspective did not differentially affect performance gains, with both views yielding similar results at the various levels of analysis.
Impact of Perspective on Primary Measures

Consistent with our hypothesis, MP reduced impairments and improved function when combined with occupational therapy, regardless of perspective. This finding adds to a growing body of literature suggesting that MP is an effective intervention to enhance arm and hand recovery after stroke (for a review, see Nilsen et al., 2010), although our data, however, do not support this suggestion. We postulated that if the benefits seen in MP were attributable to similarities in neural activity between simulated and executed action (Jeannerod, 2001), internal imagery would be optimal, but this hypothesis was not supported. Although our findings are consistent with previous studies in healthy people that found that MP from both perspectives can improve motor performance (Hardy & Callow, 1999; Weigardt, 1997), it remains unclear why the benefits were comparable.

A possible explanation comes from studies suggesting that people may be able to access the same action representation from either perspective (Anquetil & Jeannerod, 2001; Calmels, Holmes, Lopez, & Naman, 2006). Calmels et al. (2006) found that the total time to imagine a vault matched actual execution times, regardless of perspective, in skilled gymnasts. This finding led the authors to speculate that the gymnasts were able to access the same action representation from each perspective. Consistent with this notion, Anquetil and Jeannerod (2007) found that when healthy people executed grasping movements or simulated the movements from the first- or third-person perspective, the mean response times in the simulated conditions increased in a manner consistent with the difficulty of the task. More important, these increases in response times were similar regardless of imagery perspective, causing the authors to conclude that simulated actions from the two perspectives share a common action representation.

Thus, participants in the external group may have been able to access the needed action representation. Interestingly, researchers have highlighted the similarities in neural activity between action execution and observation and the possible benefits of observational learning by means of the “mirror neuron system” for neurorehabilitation (Garrison, Weinstein, & Aziz-Zadeh, 2010). According to White and Hardy (1995), the perceptual information contained in an internally generated external image is comparable to the information one gains when watching a model. Thus, in theory, when people use an external view, they are engaging in covert action observation. Although speculative, it is plausible that the benefits gained from MP using an external perspective may be akin to the benefits obtained from observational learning.
Impact of Perspective on Secondary Measure

Surprisingly, MP did not have an additive effect at the self-perception level of analysis: All participants reported improved performance and enhanced satisfaction on both trained and untrained tasks. Previous studies investigating the effects of perspective taking on motivation and self-perception found the external perspective to be preferential (Libby et al., 2007; Vasquez & Buehler, 2007). In those studies, participants were asked to imagine activities they planned to perform in the future, and the researchers assessed their motivation to perform the activities and the importance participants placed on them. In our study, participants received actual task training. Perhaps the training received during occupational therapy was sufficient to produce the improvements seen. Alternatively, because our measure did not capture motivation to perform the tasks or the importance participants placed on the activities, we may have missed the potential benefits of the training in this regard.

It is interesting that participants reported improvement in the untrained tasks as well, which may suggest that generalization of learning occurred (see also Gordon et al., 2011). Whether participants engaged in these tasks at home, however, is unknown. Although we encouraged participants to maintain their normal routines, we did not query participants about those daily routines. Curiously, control participants who made little improvement at the impairment or activity limitation levels of analysis reported improved performance. This finding highlights the disparity often seen between clinical measures of improvement and the person’s sense of recovery (Owens et al., 2002). Previous studies have shown a positive impact of MP on the relearning of functional tasks and the generalization of this learning to untrained tasks (Liu et al., 2009). It is conceivable that our results might have been different had we measured actual task performance.

Implications for Occupational Therapy Practice

Given that most stroke survivors have impairments in UE function that limit their ability to engage in valued occupations, it is imperative that occupational therapists continue to identify and test the effectiveness of interventions that target remediation of arm and hand function. Our results indicate that MP, when combined with purposeful activity, is effective at improving UE recovery poststroke. To summarize,

- Mental practice of functional tasks should be incorporated into occupational therapy programs to improve arm and hand function during poststroke recovery.
- Preliminary data suggest that clients may be able to self-select either imagery perspective from which to mentally practice functional tasks.

Limitations and Future Research

The small sample size, lack of blinding of the interventionist, and failure to question participants about MP use or activities engaged in at home are study limitations. Additionally, we did not stratify randomization by involved side. Lesion location may have played a role in the ability to use MP. However, other researchers have postulated that lesion location alone does not determine imagery ability (Malouin, Richards, Durand, & Doyon, 2008; Simmons, Sharma, Baron, & Pomeroy, 2008). Because we assessed our participants for imagery ability, it is probable that we screened out people with compromised imagery capability, likely minimizing the extent to which side of lesion affected our results. Nevertheless, the relationship merits further investigation. Stratified randomization procedures that control for other potential confounding variables (e.g., age, time poststroke, impairment level) are also needed.

Conclusion

When combined with occupational therapy, MP is an effective intervention to improve arm and hand recovery. MP does not, however, appear to have an effect on client perceptions of occupational performance. Instruction for imagery perspective does not appear to be an important variable for the success of MP interventions; both perspectives produced similar results at the various levels of analysis.

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