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# Use of mental imagery to improve task generalisation after a stroke

**Key Messages**

Patients who received mental imagery intervention showed better performance on 15 daily tasks than the control group in both the training environment (P=0.02) and a novel simulated environment (P<0.05).

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## Introduction

Stroke rehabilitation aims to help people regain lost functions and reintegrate into the community. Previous studies have reported the positive effects of mental imagery (MI) on learning.[1,2] Mental imagery involves memory retrieval, and the generation and maintenance of images.[3] It is believed that generating the image, 'seeing the performance of the behaviour with the mind's eye', prior to performance of the task, activates neural substrates that are subsequently involved in the actual performance of the task. This effect is thought to facilitate the planning and execution of the task, thereby increasing the level of independent task performance.[1,2]

Mental imagery has been applied to stroke rehabilitation to promote upper limb motor function and visual neglect. Our previous randomised controlled trial indicated that patients receiving 3 weeks of MI intervention performed daily tasks better than those receiving conventional rehabilitation.[1] These findings demonstrated that MI could enhance the relearning of lost functions, possibly via active control of the task performance.

Generalisation demands that a person modify, assimilate and apply the skills learned in one environment to fit another environment.[4] In the context of rehabilitation for people with brain injuries, the skills learned in hospital after a brain injury need to be generalised to a different environment. The extent to which skills learned in the hospital environment are generalised to the home environment contributes to the success with which the person reintegrates into the community and is able to lead a normal life.

This study investigated the benefits of an MI intervention to enhance performance of tasks in a novel environment for post-stroke patients. A randomised clinical trial was used to compare the generalisation of daily task performance across different environments using an MI intervention and a functional rehabilitation (FR) programme.

## Methods

This study was conducted from July 2005 to June 2006.

### *Study design*

This study adopted the same single-blind, randomised control design as our previous study.[1] Based on our previous results, a sample of 17 patients per treatment group was adequate for having an 80% likelihood ($\beta$=0.20) of detecting a 20% difference ($\alpha$=0.05) in improvement between groups. After giving their informed consent, patients were randomised by drawing lots for either the MI or FR programmes. The relevant hospital ethics committee approved the study.

### *Patients*

Thirty-four patients who had experienced a first acute stroke were recruited. Patients were included if they sustained unilateral cerebral infarction within the middle carotid artery system, were aged over 60 years, were independent in their daily activities before the stroke, were able to communicate effectively and were cognitively intact when assessed using a validated neurocognitive functioning test (Cognistat, Northern California Neurobehavioral Group, CA, US). One

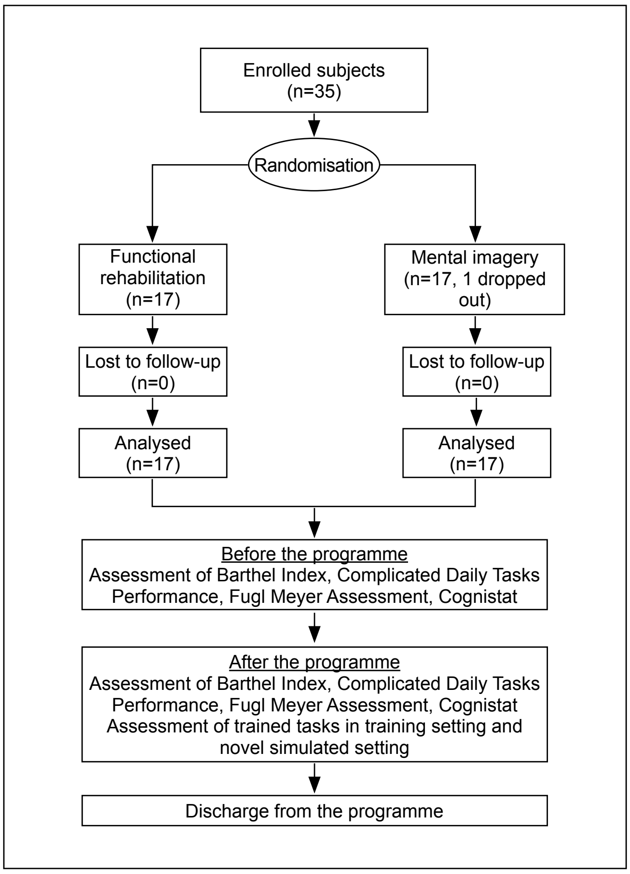


**Fig . Flowchart of the trial**

patient in the MI group dropped out after recruitment but before the intervention started because of persistent fever and unstable medical problems (Fig).

### *Intervention*

The patients were treated within 3 days of being transferred from an acute hospital and within 1 month of the onset of their strokes. Patients in the MI group received 1 hour of MI per treatment and those in the FR group were given conventional occupational therapy. All treatment protocols were administered five times a week for 3 weeks (a total of 15 treatments). Patients in both groups received similar levels of therapist attention during their programmes. All patients had 1 hour of physical therapy daily that involved mobilisation, strengthening, and walking exercises.

All patients were trained to relearn 15 daily tasks. Five tasks with a similar level of difficulty were covered each week, progressing from the easiest to the most difficult. The MI intervention involved the patients' self-reflection on their abilities and deficits: mentally imagining, then actually performing, the task. The average time spent on MI and in actual practice was 30 minutes each. In the FR group, patients were given conventional occupational therapy using demonstration-and-practice methods to train them to perform the same 15 daily tasks. Experienced stroke rehabilitation therapists who had received training in the relevant techniques administered the MI intervention and FR programmes.

**Table 1. Characteristics of patients in the functional rehabilitation (FR) and mental imagery (MI) groups***

| Characteristics | FR (n=17) | MI (n=17) |
|---|---|---|
| Age (years) | 68.1±10.5 | 70.4±9.8 |
| Gender | | |
| Male | 12 (70.6) | 9 (52.9) |
| Female | 5 (29.4) | 8 (47.1) |
| Days since stroke at inclusion | 12.3±7.4 | 12.3±5.3 |
| Location of stroke | | |
| Left hemisphere | 5 (29.4) | 5 (29.4) |
| Right hemisphere | 12 (70.6) | 12 (70.6) |
| Barthel Index (score) | 51.1±20.9 | 55.2±13.6 |

* Data are shown as mean ± standard deviation, or No. (%)

### *Outcome measurements*

The patients' performance on the five tasks they had been trained was assessed in both the training environment (where the intervention had been provided) and a novel simulated environment (where 'real life' environments like home and community were simulated) to determine whether the skills learned could be generalised across environments. The task performance was rated using a 7-point Likert scale with '1' indicating 'complete dependence' and '7' indicating 'complete independence'. The inter-rater reliability ranged from 0.89 to 0.97; the assessors were blinded to the nature of the intervention. The Fugl-Meyer Assessment (FMA) of sensorimotor recovery after stroke[5] and the Cognistat were also assessed before and after the programme.

### *Statistics*

Descriptive statistics were used to measure the patients' relevant characteristics. Multivariate analysis of variances (MANOVA) were used to compare the difference between the MI and FR groups in terms of the changes in the task performance scores before and after the training. The data analysis was conducted using the Statistical Package for the Social Sciences (Windows version 12.0; SPSS Inc, Chicago [IL], US).

## Results

No significant differences were found in baseline values between the two groups (Table 1), indicating that they were homogenous in these measurements before treatment.

### *Performance of tasks in training and novel simulated environments*

There were significant differences between the MI and FR groups in the task performance score changes before and after training in the training environment (P=0.02), with the MI group having higher performance score changes (Table 2). The univariate tests revealed significant differences in the 'fried vegetable with meat' (P=0.01), 'tidy table after meal' (P=0.02), and 'sweep floor' (P=0.02) tasks between the two

**Table 2. Change in task performance scores before and after training between the functional rehabilitation (FR) and mental imagery (MI) groups***

| Tasks | MI (n=17) | FR (n=17) |
|---|---|---|
| Training environment | | |
| Fried vegetable with meat | 1.5±1.9 | -0.5±2.4 |
| Tidy table after meal | 1.6±1.5 | -0.1±2.3 |
| Sweep floor | 2.2±1.6 | 0.4±2.6 |
| Go to canteen | 1.0±1.3 | 0.1±2.2 |
| Go to park | 1.4±1.8 | 0.9±2.0 |
| Novel simulated environment | | |
| Fried vegetable with meat | 1.5±1.8 | -0.5±2.3 |
| Tidy table after meal | 1.6±1.5 | 0.1±2.2 |
| Sweep floor | 2.6±1.8 | 0.6±2.3 |
| Go to canteen | 1.5±1.1 | 0.1±2.2 |
| Go to park | 1.4±1.6 | -0.4±2.6 |

* Data are shown as mean ± standard deviation

**Table 3. Fugl-Meyer Assessment—change in scores before and after training between the functional rehabilitation (FR) and mental imagery (MI) groups***

| Fugl-Meyer Assessment | MI (n=17) | FR (n=17) |
|---|---|---|
| Upper limb | 2.5±2.4 | 3.1±5.2 |
| Wrist | 1.3±1.9 | 1.1±1.6 |
| Hand | 0.8±1.6 | 1.9±1.9 |
| Upper limb coordination | 0.2±0.8 | 1.9±1.3 |
| Lower limb | 3.8±7.1 | 2.8±4.4 |
| Lower limb coordination | 0.9±1.7 | 1.0±1.8 |
| Balance | 2.8±2.4 | 2.5±2.8 |
| Sensation | 0.4±3.2 | 1.3±2.7 |
| Passive range of motion | 0.2±1.0 | -0.9±2.7 |
| Joint pain | -0.1±1.7 | -0.6±2.7 |

* Data are shown as mean ± standard deviation

groups. No significant difference was found between the two groups in the 'go to canteen' (P=0.14) and 'go to park' (P=0.49) tasks.

There were significant differences between the MI and FR groups in the task performance score changes before training in the training environment and after training in the novel simulated environment (P≤0.05), with the MI group achieving higher performance score changes (Table 2). The univariate tests revealed significant differences in all five tasks between the two groups ('fried vegetable with meat' (P=0.008), 'tidy table after meal' (P=0.02), 'sweep floor' (P=0.01), 'go to canteen' (P=0.03) and 'go to park' (P=0.03).

### *Motor function: Fugl-Meyer Assessment of sensorimotor recovery after stroke*

The results of the FMA are shown in Table 3. Higher scores indicate better motor function. The MANOVA of the change in pre- and post-programme scores showed that there was a significant overall effect ($\underline{F}$ (10, 23)=2.93, P=0.016). The FR group had a better performance than the MI group. Univariate results indicated significant between-group effects in upper limb coordination (P<0.001).

**Table 4. Cognistat—change in scores before and after programme between the functional rehabilitation (FR) and mental imagery (MI) groups***

| Cognistat | MI (n=17) | FR (n=17) |
|---|---|---|
| Orientation | 0.2±1.1 | 0.2±1.4 |
| Attention | 0.0±0.0 | 0.2±1.2 |
| Comprehension | 0.0±0.0 | 0.2±0.6 |
| Repetition | -1.4±2.7 | -0.7±3.1 |
| Naming | -0.2±1.2 | 1.7±0.7 |
| Construction | 0.1±1.6 | 0.5±1.4 |
| Memory | 0.8±2.2 | 0.5±2.1 |
| Calculation | 0.1±0.9 | -0.1±0.7 |
| Similarities | 0.6±1.6 | 0.5±1.1 |
| Judgement | 0.2±0.7 | 0.1±0.8 |

* Data are shown as mean ± standard deviation

### *Cognitive function: Cognistat*

The results of the Cognistat are shown in Table 4. Higher scores indicate better cognitive function. The MANOVA showed no significant difference between the groups ($\underline{F}$ (10, 23)=0.70, P=0.71). Univariate results indicated no significant between-group effects in changes in pre- and post-programme scores in all subscales.

## Discussion

### *Effects of the mental imagery programme on task performance*

To investigate the effect of MI training on stimulus generalisation, a task competence assessment was conducted in the training (familiar) environment and then repeated in a novel simulated environment. When compared with the training environment, the novel simulated environment should be more difficult and make more demands on patients as they had not yet come across these environments after sustaining their strokes. It should require more effort to generalise learned skills to the novel simulated environment. These tasks are what they would experience and carry out at home and in the community after discharge.

The results of the MANOVA on the pre- and post-training task performance score changes showed that the patients in the MI group scored significantly higher than those in the FR group in the novel simulated environments. This suggests that the patients who had received MI training were able to generalise what they had learned to the new situation better than the FR group. This finding is consistent with our previous findings that the patients in the MI group appeared to be able to relearn skills and tasks better.[1] Those in the FR group also showed general improvement in tasks tested in both training and novel simulated environments, but they performed less well than their counterparts in the MI group. As the patients in the FR group received the demonstration-and-practice method of task retraining, they might have found it difficult to copy exactly what was learned in the training environment when tested in a novel simulated environment. The MI approach is a better learning strategy for patients with strokes who might find it difficult to generalise the skills they have learned.

Our previous study showed that relearning daily tasks was more effective when active learning processes were involved.[1] Active learning refers to self-directed participation in the process of gaining skills and knowledge, using the techniques of chunking (to break down the task into steps) and self-regulation (to identify, correct and self-reflect on own problems). In a study of patients who had suffered global brain damage, active participation in motor training appeared to be a more effective way of enhancing performance than the use of a passive mobilisation protocol.

Patients in the MI group performed slightly better than those in the FR group in only three tasks in the training environment, but all five tasks were better performed in a novel simulated environment (Table 2). This means that generalisation of skills learned to novel simulated environment is found to occur more significantly in the MI group than in the FR group. It was expected that the training environment would be easier to deal with than the novel simulated environment to which the patients had not been exposed before. As the patients in the FR group received largely rote-learning methods for task retraining, they might have found it difficult to copy exactly what was learned in the training environment when tested in the novel simulated environment, especially in those tasks where environmental factors contributed markedly to the task difficulty as in 'go to park' or 'go to canteen'. This may be the reason that patients in the FR group performed less well in 'go to park' and 'go to canteen' in the novel simulated environment than patients in the MI group. As the novel simulated environment resembled patients' homes or communities, patients in the MI group might have applied chunking to identify the task demands and self-regulation to identify possible problems, and hence solutions, and then MI to collate information about the task demands and the patient's physical abilities. This could be the reason that patients in the MI group performed better than those in the FR group in the novel simulated environment.

Patients in the FR group performed the task 'go to park' significantly worse in the novel simulated environment (from 4.5 to 3.2). In contrast, the patients in the MI group maintained their performance level at 4.6. This further substantiates the proposition that MI can enhance skills generalisation, which is essential for task performance in the outdoor environment. This is particularly important when the environment is more unpredictable and continuously changing, such as when community facilities and shopping areas are being refurbished or remodelled. Our results suggest that the patients who were trained in the MI programme developed useful strategies for dealing with new situations. Positive and successful experiences give these patients more confidence when exposed to new environments and enable them to become more adaptive. In comparison, patients in the FR group might be less adaptive to different environments. The conventional FR approach used in rehabilitation might help them to relearn lost functions but may not adequately equip them with the skills needed for community reintegration.

With the help of chunking and self-regulation to facilitate the learning of the lost discrete skills after brain injury, the effectiveness of MI is enhanced by enabling individuals to mentally practise the task with corrected methods that are permitted by the bodily constraints caused by the brain injury. Motor planning for the task performance can therefore be maintained. During stimulus generalisation, MI helps to transfer the established behaviour to another setting through mental practice of the behaviour within the context of another setting. This helps the individual to plan the task and adapt to the different environment while mentally practising the task. Mental imagery helps to transfer the behaviour even under the possibly distracting stimuli in another setting. This enhances the task performance with the realisation of bodily constraints and differences in environment. Mental imagery therefore helps to facilitate the re-establishment and synchronisation of relevant behaviour with the realisation of bodily constraints caused by brain injury.

### *Effects of mental imagery on the Fugl-Meyer Assessment of sensorimotor recovery after stroke and Cognistat*

All patients showed significant improvement in the basic functional outcome measure, the Barthel Index. As indicated from the overall score, they changed from requiring moderate assistance in most self-care tasks to requiring only minimal assistance. As with task performance, the patients in the MI group had better scores than the FR group after the programme. The lack of significant difference in the improvement between the two groups could be attributed to a possible ceiling effect on performance.

Generally, all patients showed improved motor function after training, as reflected by their FMA scores. Patients in the MI group had significantly better improvements in 'upper limb coordination'. This result contrasts with previous findings on improvement of motor performance; this might be due to differences in the nature of the imagery programmes. Page et al[6] used a motor imagery programme where subjects performed imagery of motor movement. Our study focused more on training the patients to perform daily tasks by incorporating their own dysfunction into it. This might explain why patients in the MI group did not have better FMA scores than those in the FR group.

In our previous studies,[1,2] we postulated that the MI programme would enhance the patients' attention and sequential processing. In the present study, there was no significant difference between groups on all subscales of the Cognistat. These results seem to contrast with our previous findings,[1] but this might be due to the relative insensitivity of Cognistat as a measure of attention. Cognistat is used more often as a mental screening tool.

## Conclusions

This study provides evidence of the positive effects of the MI for improving patients' generalisation of task performances to new environments. It offers further evidence concerning the role of active control, which can be mediated by MI to enhance the relearning potential of people with stroke. Although MI seems to improve patients who are cognitively intact (as in those recruited for this study), strategies to further enhance the use of MI in patients with different profiles and ability levels are worth investigating. Moreover, the length of the programme could be further investigated so that it may be modified to fit the needs of specific rehabilitation programmes. This study only looked at the outcome immediately after the programme. The carry-over effect, which is important to a patient's reintegration into the community after discharge from hospital, is also important, and this will require further investigation. The positive effect of MI shown in both this and previous studies indicates that it is worth looking at the effectiveness of MI in terms of more global outcomes, such as quality of life and integration into daily life.

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