

Efficacy of Task-Oriented Mirror Therapy on Enhancing Functional Recovery for Unilateral Neglect Post Stroke

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ABSTRACT

OBJECTIVE Stroke is a neurological condition with multiple complications, one of the most common being Unilateral Spatial Neglect (USN), where patients lose awareness of one side of their body. Both task-oriented mirror therapy and task-oriented therapy can aid in improving functional performance. The objective of the study was to compare the efficacy of task-oriented mirror therapy with task-oriented therapy in improving functional recovery among patients with USN.

METHODS This was a comparative study of 30 individuals. Using the sealed envelope method, participants were randomly assigned into group A or group B with 15 individuals in each group as per the inclusion and exclusion criteria. Group A was administered task-oriented mirror therapy and group B was administered task-oriented therapy. The therapy sessions were conducted for 45 minutes daily, 5 times a week, over a span of 4 weeks. The outcome measures were evaluated using the Catherine Bergego Scale (CBS) and the Line Bisection Test.

RESULTS Task-oriented mirror therapy had a greater impact on unilateral spatial neglect compared to task-oriented therapy without a mirror. A notable difference was found in the post-test mean and standard deviation values for CBS in group A [8.20 ± 2.624] and Group B [15.07 ± 3.105], as well as for line bisection test in group A [7.27 ± 1.534] and Group B [14.53 ± 2.973], both with a $p < 0.001$.

CONCLUSION Task-oriented mirror therapy showed better improvement in functional outcomes for patients with unilateral spatial neglect compared to task-oriented therapy.

KEYWORDS Catherine Bergego Scale, Line bisection test, post-stroke, rehabilitation

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INTRODUCTION

Stroke is a neurological condition resulting from vascular damage to the central nervous system, with hypertension being a key risk factor (1). Stroke is prevalent among patient populations and can cause significant morbidity and mortality.

Strokes are classified as ischemic and haemorrhagic strokes (2). The Trial of ORG 10172 in Acute Stroke Treatment (TOAST) classification system divides cerebral ischemia patients into five distinct categories: major artery atherosclerosis, cardioembolism, small vessel occlusion, stroke

of other determined causes, and stroke of undetermined origin (3). Globally, approximately 11.6 million ischemic strokes (IS) and 5.3 million hemorrhagic strokes (HS) occur annually. Notably, low- and middle-income countries contribute to 63% of IS cases and 80% of HS cases (4) although they represent only 54% of the world population.

Unilateral spatial neglect (USN) is a condition characterized by impaired awareness of the contralesional space. Individuals with USN fail to respond to various stimuli or situations originating from the side opposite to their brain lesion, despite having intact sensory and motor functions (5).

USN occurs frequently, affecting approximately 25–30% of stroke victims, with over 90% of cases involving lesions in the right hemisphere. In the acute phase, USN is observed in 20% of individuals with left-hemisphere lesions (LHL) and 43% of those with right-hemisphere lesions (RHL). After three months, USN persists in 17% of RHL patients and 5% of LHL patients (6).

Spatial neglect can be classified into egocentric and allocentric types using a spatial representation framework. Individuals with egocentric (body-centered) neglect tend to overlook their own body or personal space, while those with allocentric (stimulus-centered) neglect fail to attend to the contra-lesional side of external stimuli (7).

Rehabilitation strategies for USN include diverse methods such as robotics, virtual reality, and prism adaptation training. Robotic-assisted therapy, in particular, has shown potential in enhancing midline orientation and spatial awareness; however, it has not shown significant effects on functional performance (8). Virtual reality interventions hold promise for treating USN, but there is a lack of high-quality randomized trials to substantiate their efficacy (9). Prism adaptation training has been shown to reduce symptoms of USN, though its beneficial effects tend to be short-lived (10).

The fundamental concept of mirror therapy (MT), a low-cost patient-centered technique, is based on creating a visual illusion using the mirror reflection of the unaffected limb. Additionally, MT may activate mirror neurons and/or the primary motor, sensorimotor, and premotor cortex. A previous study using functional MRI analysis demonstrated that human mirror neurons are more strongly activated during functional move-

ment than during normal movement (11, 12). This approach gives patients the impression that their paralysed limbs are still intact by emphasising their healthy, unaffected limbs (13). Mirror therapy can enhance performance of activities of daily living (ADL), reduce pain and symptoms of unilateral neglect, and improve physical function in the paretic upper and lower limbs (14). Task-oriented Training for treating upper extremity impairment in chronic stroke patients appears to be a promising intervention strategy. This approach has shown improvements in motor function (15).

While numerous articles compare MT with other interventions, there is a lack of research specifically comparing task-oriented mirror therapy with task-oriented therapy without a mirror. Additionally, many therapies primarily focus on the upper limb activities, but there is a lack of specific research that includes lower limb activities. The aim of this study is to compare the effectiveness of task-oriented MT with task-oriented therapy in enhancing functional recovery.

METHODS

This study was conducted in a private setting on patients with unilateral neglect. Sample size determination was performed using G*power software with alpha 0.05 and power beta 0.95 and an effect size of 0.5. The calculated sample size was 42 (Figure 1). Due to dropouts and elimination of some potential participants, the final sample size was 30. The participants were selected according to predefined inclusion and exclusion criteria. Using the sealed envelope method, participants were randomly assigned into one of two groups, group A and group B, with 15 individuals in each group. Group A received task-oriented MT, while group B received task-oriented therapy without a mirror. Allocation concealment was maintained using opaque sealed envelopes which were opened after participant details were written. After receiving an explanation of the techniques, all participants provided written informed consent. The blinding of assessors was done primarily to avoid an assessment bias, ensuring that assessors measuring the functional recovery outcomes were unaware of the group assignments. The subjects in both groups underwent therapy for 45 minutes daily, 5 times a week, over a span of 4 weeks. Outcome measures were evaluated

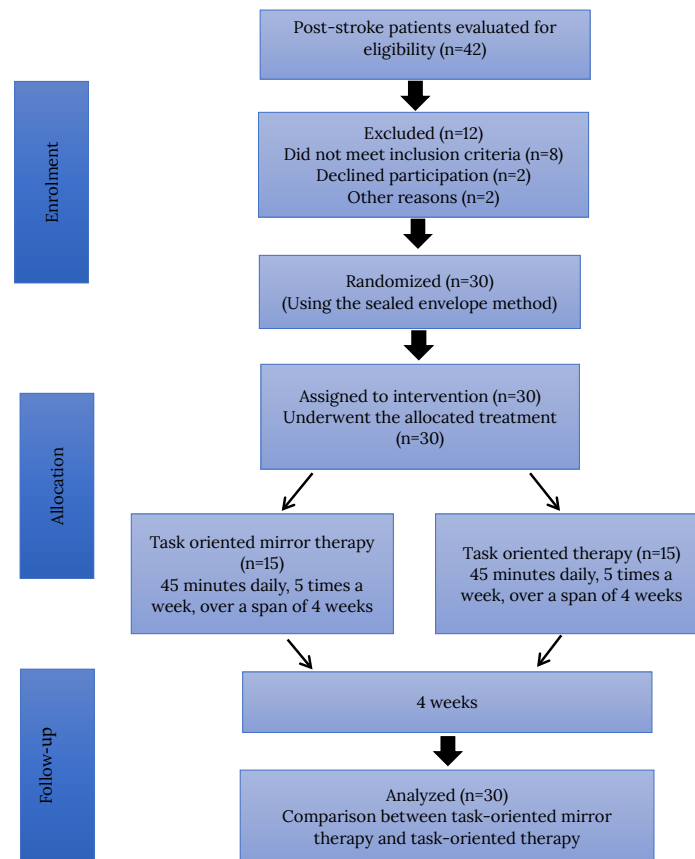


Figure 1. Study selection flow chart

using the Catherine Bergego Scale (CBS) and the Line Bisection Test (LBT) both before and after the treatment.

Ethical clearance

The study was conducted in accordance with the ethical committee on human experimentation of institution ISRB on 376/07/2024/ISRB/UGSR/SCPT.

Inclusion criteria

The study included subjects with unilateral neglect following a stroke, specifically those who exhibited a positive sign on the line bisection test and had a score of more than 10 on CBS, indicating a significant level of neglect. Participants aged between 40 and 70 of both genders were considered eligible for inclusion.

Exclusion criteria

Subjects who had undergone recent surgery or had fractures were excluded from the study to avoid any potential health risks and complications. Additionally, individuals diagnosed with depression, limb weakness not caused by stroke,

other perceptual disorders, or significant visual deficits were also excluded. Furthermore, participants deemed unsuitable by the attending physician were excluded.

Treatment procedure

Group A

Group A underwent task-oriented MT. The mirror was placed vertically in front of the unimpaired limb, with the impaired limb positioned behind the mirror. The subjects performed tasks using the unimpaired limb while focusing on the mirror's reflection which showed the movement of the impaired limb. For the upper limb, a standard mirror was placed on the table, while for the lower limb a larger mirror was positioned vertically between the legs, with the impaired leg placed behind the mirror. A one-minute break was given after every two exercises.

Group B

Group B underwent task-oriented training without a mirror. The subjects performed tasks using the impaired limb with additional cues and manual assistance. A one minute break was given after every two exercises.

Upper limb tasks: (25 minutes per session)*Grasping and releasing balls*

This task involved squeezing and releasing sponge balls, repeated 10 times (16).

Using a spray bottle

In this task, the bottle was filled with water, and the subject was asked to spray the water by squeezing the bottle. The subject was instructed to spray water 10 times (16).

Kneading putty

In this task, the subject was asked to create clay models using clay or putty. They were instructed to make 2 or 3 models (16).

Pinching coins

The task involved pinching a coin between the thumb and index finger. The subject was asked to hold the coin for 2-5 minutes (16).

Using a spoon

In this task, the subject was asked to transfer marbles or beans from one bowl to another using a spoon. They were instructed to fill the entire bowl (16).

Lifting a heavy can (shown in Figure 2).

For this task, the subject was asked to lift the cans or water bottles filled with water and to repeat the action 10 times (16).

Wiping a table with a cloth

The subject was asked to wipe a table using either a wet cloth or a dry cloth. They were instructed to wipe the entire table (16).

Picking up objects with tongs

In this task, the subject was asked to pick up different objects using a pair of tongs (16).

Lower limb tasks: (20 minutes per session)*Rocker or wobble board*

In this task, the subject was seated with their feet on a rocker board. They were instructed to rock the board back and forth, side to side, and in circular motions, repeating each movement 10 times (17).

Foot roller

The subject was asked to sit with one foot placed on a foot roller. They were instructed to roll their foot back and forth over the roller while applying gentle pressure, repeating the action 10 times (17).

Picking up sticks/curling cloth with toes

In this task, the subject sat with objects (such as sticks or cloths) on the floor in front of them. They were instructed to pick up the objects using

their toes, either one at a time or several at once, and to attempt to pick up all the objects (17).

Kicking the ball

In this task, the subject sat with the ball in front of them. They were instructed to kick the ball by performing knee extension, repeating the action 10 times (18).

Rolling the ball

In this task, the subject sat with the ball in front of them. They were instructed to roll the ball forward and back using their leg, repeating the action 10 times (18).

Outcome measure*Catherine Bergego Scale*

The CBS includes 10 components, each comprising a set of questions related to activities of daily living. Each component is scored from 0 to 3, where 0 signifies no neglect, 1 indicates mild neglect, 2 represents moderate neglect, and 3 denotes severe neglect. The total score ranges from 0 to 30, with 0 indicating no neglect, 1-10 suggesting mild behavioural neglect, 10-20 reflecting moderate behavioural neglect, 21-30 signifying severe behavioural neglect, and a score of 30 representing a more severe form of neglect.

The internal validity of the Catherine Bergego Scale found unidimensionality of items by Rasch analysis. All categories of the Korean Kessler Foundation Neglect Assessment Process (KF-NAP) showed high internal consistency (19). The CBS is an adequate and validated scale for assessing patients with USN after stroke. The CBS is more sensitive than pen-and-paper tests for USN detection (20).



Figure 2. Lifting a heavy can

Line Bisection Test (LBT)

The LBT is used to identify the presence of unilateral spatial neglect. During the test, the participant is instructed to mark the midpoint of a series of horizontal lines using a pencil. Typically, the mark deviates towards the side of the brain lesion.

Studies have shown excellent test-retest reliability, with values ranging from $r = 0.84$ to $r = 0.93$. Another study reported adequate test-retest reliability (Pearson $r = 0.64$) (21). The LBT has construct validity for determining the presence of Unilateral Neglect (ULN). One study showed a correlation between the LBT and the Star Cancellation Test ($r = 0.48$) (21).

Data analysis

The statistical analysis in this study was conducted using IBM SPSS software version 30.0.0.0. A paired t-test was used to compare task-oriented MT and task-oriented therapy, assessing the differences between pre-test and post-test scores from the CBS and the LBT. Additionally, an unpaired t-test was conducted to compare post-test results between the two groups.

RESULTS

The result showed significant improvements in functional outcome in both groups, with a $p < 0.001$. Baseline characteristics of patients are summarized in Table 1. In group A (mirror), the CBS scores (mean $\pm$ SD) decreased from 17.20 ± 3.590 to 8.20 ± 2.624 (Cohen's $d = 2.87$), while in Group B (no mirror), they decreased from 17.40 ± 3.019 to 15.07 ± 3.105 (Cohen's $d = 0.98$).

Similarly, in the LBT, group A improved from 14.87 ± 3.091 to 7.27 ± 1.534 (Cohen's $d = 2.09$), whereas Group B improved from 15.87 ± 2.997 to 14.53 ± 2.973 (Cohen's $d = 0.49$). Statistical analyses are shown in (Table 2-5).

Post-test comparisons confirmed that Group A showed better reductions in scores compared to group B, indicating a more significant enhancement in functional outcomes. The results demonstrate that task-oriented MT led to significant improvements in functional rehabilitation compared to task-oriented therapy without a mirror.

Table 1. Baseline comparison between group A and group B

Variable	Group A	Group B
Age (Mean $\pm$ SD)	54 $\pm$ 8.15	55.4 $\pm$ 9.14
Mini Mental Scale Examination (MMSE)	25 $\pm$ 1.30	25.06 $\pm$ 1.16
BMI (Mean $\pm$ SD)	24.06 $\pm$ 1.06	24.3 $\pm$ 1.42
Gender (M/F)	7/8	8/7
Comorbidities		
Diabetes	8	7
Hypertension	3	5
Dyslipidemia	4	3

*SD, standard deviation, *BMI, body mass index

Table 2. Pre and post-test values of CBS in group A and group B

Groups	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	t-value
Group A (N = 15)	17.20 $\pm$ 3.590	8.20 $\pm$ 2.624	18.825
Group B (N = 15)	17.40 $\pm$ 3.019	15.07 $\pm$ 3.105	9.260

SD, standard deviation; CBS, Catherine Bergego Scale

Table 3. Pre and post-test values of Line Bisection Test in group A and group B

Groups	Pre-test Mean $\pm$ SD	Post-test Mean $\pm$ SD	t-value
Group A (N = 15)	14.87 $\pm$ 3.091	7.27 $\pm$ 1.534	14.032
Group B (N = 15)	15.87 $\pm$ 2.997	14.53 $\pm$ 2.973	10.583

SD, standard deviation

Table 4. Post-test values of CBS and Line Bisection Test in group A

Test	Mean	SD value	t-value
Post-test (Line bi-section test)	7.27	1.534	-8.413
Post-test (CBS)	8.20	2.624	-6.542

SD, standard deviation; CBS, Catherine Bergego Scale

Table 5. Post-test values of CBS and Line bisection test in group B

Test	Mean	SD value	t-value
Post-test (Line bisection test)	14.53	2.973	-8.413
Post-test (CBS)	15.07	3.105	-6.542

SD, standard deviation; CBS, Catherine Bergego Scale

DISCUSSION

In adults, stroke is the most common cause of long-term impairment. Stroke is the second most common cause of death and disability globally, and the highest illness burden is found in low- and middle-income nations (22). In our study, we compared task-oriented MT (group A) and task-oriented therapy without a mirror (group B) for USN in post-stroke patients. By comparing the mean values and SD for Group A and Group B, it was evident that task-oriented MT had a better impact compared to task-oriented therapy without a mirror.

Task-oriented MT significantly enhanced functional recovery by utilizing visual feedback to reduce the symptoms of USN. This is consistent with Sim & Kwon and Pandian et al. who noted that rehabilitation techniques such as MT were effective in the treatment of USN. This form of therapy works by using a mirror to provide visual feedback to the brain, tricking it into thinking that there is movement or sensation on the neglected side. This process may provide support for neural circuitry, allowing for better motor functioning and diminishing symptoms of neglect (14, 17). Utilisation of visual input, particularly using MT, has been identified as enhancing functional outcomes better than conventional task-orientated therapies without visual feedback. Fong et al. provided initial evidence of the therapeutic advantages of MT for treating patients with stroke and spatial neglect. Their observations revealed how mirror-induced visual feedback assists in mitigating symptoms of neglect by prompting attention to the neglected side. This process triggers cortical reorganisation and facilitates neuroplasticity, ultimately improving spatial awareness and

functional recovery. Mirror therapy is therefore a worthwhile adjunct to traditional rehabilitation techniques in patients with spatial neglect (7).

Task-oriented mirror treatment improves spatial awareness and visual-spatial integration and reduces symptoms of spatial neglect. This seems to be beneficial to the patient and is consistent with Klinkwan et al.'s physiological findings from 2021. Even though motor rehabilitation played a significant role in their study, they also suggested that mirror treatment would be able to reduce neglect by activating the neglected side through visual input (23).

Although psychology was not the primary focus of our research, the research literature recommends that MT can also provide some significant psychological and motivational advantages. Mirror therapy has been proven to enhance patients' moods and confidence, which can, in turn, have a positive effect on their level of rehabilitation engagement. The process of performing normal movement can help overcome the feeling of helplessness and enhance emotional well-being. However, the psychological effects have been suggested to be limited in patients with more significant impairments and those who find it hard to stay motivated during therapy. This highlights the need for further studies to improve the psychological effects of MT in various populations (7, 24).

In our study, we found that task-orientated therapy had beneficial effects on the participants similar to previous studies. For example, Pathan demonstrated that task-orientated training contributed to improvements in motor ability and functional outcomes in adults with chronic stroke, but noted that there were inconsistencies with improvements in activity-based outcomes.

This may mean that while task-orientated approaches can have a substantial effect on stroke rehabilitation, there could be variability based on the utility of the task and the individual characteristics of the challenge or goal, demonstrating a need for further individualised rehabilitation approaches (25).

Even though our findings are positive, some research has indicated that not all stroke patients respond favourably to MT. Their response often depends on personal expectations, which can reduce their motivation if outcomes do not meet their hopes. Only some stroke patients respond positively to MT; for others, it may cause frustration or decrease their motivation if no progress is shown (24). In our study, providing participants with consistent feedback and clearly defined goals contributed to positive outcomes.

In summary, our research showed that compared to task-oriented therapy without a mirror, task-oriented MT greatly improves functional recovery and spatial awareness in USN patients. The effect of visual feedback as provided with the use of MT in combination with the extremity task was vital in facilitating reactivation of pathways in the brain, reduction of symptoms of neglect, and enhancement of ADL. This supports the use of the task-oriented MT, a promising therapeutic approach that utilises the mirror neurones to improve functions and the quality of life of stroke patients with USN syndrome.

Limitations and future hope of the study

This study has some limitations that need to be explained. Due to the nature of the intervention, participants were aware of the type of treatment provided; double-blinding was not possible. The study included only a limited number of participants. Even though the sample size calculation was done using G* power software to determine whether the sample size was efficient, a larger sample size is needed to increase the reliability of the findings. Additionally, the course of treatment was only four weeks. A longer follow-up is needed to evaluate the durability of the therapeutic effects.

Further advances in technology, interdisciplinary approaches, and personalised treatment strategies might enhance the use of task-orient-

tated MT for unilateral neglect post stroke. Incorporating neuroimaging techniques like fMRI or EEG could potentially provide insights into cortical changes associated with MT. Comparing recent innovations such as virtual reality and non-invasive brain stimulation could potentially improve effectiveness and should be incorporated in future studies.

CONCLUSIONS

The research demonstrated that task-oriented MT is more effective than task-oriented therapy without a mirror. Mirror therapy enhances the functional outcome and spatial awareness of patients suffering from unilateral spatial neglect. The results point to the fact that both mirror neurons and visual stimuli greatly aid in enhancing the functional outcome and symptoms of unilateral neglect in the individual.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

AUTHOR CONTRIBUTIONS

D.S.: conceptualization, methodology, formal analysis, and manuscript drafting, assistance in data acquisition and formatting of the final manuscript; K.D.: data collection, investigation, and literature review, project administration and coordination of research activities; P.S., P.K.: supervision, validation, and critical revision of the manuscript; R.V., V.J.: statistical analysis and data interpretation; V.S.: visualization, graphical representation, and proofreading.

DATA AVAILABILITY

The data can be given by the corresponding author with reasonable requests.

INSTITUTIONAL REVIEW BOARD STATEMENT

This study was approved by the Institutional Scientific Review Board of Saveetha College of Physiotherapy (Approval Number: 376/07/2024/ISRB/UGSR/SCPT, approval date July 10, 2024). All procedures were conducted in accordance with institutional ethical standards and the Declaration of Helsinki.

INFORMED CONSENT STATEMENT

Written informed consent was obtained from all individual participants involved in the study.

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