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IMPACT OF PERFORMANCE AWARENESS COMPARED TO OUTCOME AWARENESS ALONGSIDE MIRROR THERAPY ON ENHANCING HAND FUNCTION IN PATIENTS WITH CHRONIC STROKE

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ABSTRACT

Background: Stroke is the leading cause of serious long-term disability in adults, and more than 60% of stroke survivors suffer from persistent neurological deficits that impair activities of daily living. The paretic upper limb is a common and undesirable consequence of stroke that increases activity limitation. Mirror therapy is a therapeutic intervention that focuses on moving the unimpaired limb while watching its mirror reflection superimposed over the unseen impaired limb, thereby creating a visual illusion of enhanced movement capability of the impaired limb. Augmented feedback may be provided as knowledge of performance, which concerns the nature or quality of the movement pattern produced, or as knowledge of results, which concerns the end result or overall outcome of the movement.

Objective: To compare the effect of knowledge of performance and knowledge of results when given alongside mirror box therapy in improving hand function in patients with chronic stroke.

Methods: An experimental study was conducted on 30 patients aged between 50 and 65 years with a first episode of unilateral stroke with hemiparesis during the previous 12 months. Participants were randomly allocated by the chit method into Group A, receiving knowledge of performance (n = 15), and Group B, receiving knowledge of results (n = 15). Both groups underwent 30 minutes of mirror therapy per day in addition to 50 minutes of conventional stroke rehabilitation, five days a week, for four weeks. Hand function was assessed pre- and

post-intervention using the upper limb score of the Fugl-Meyer Assessment and the Jebsen Test of Hand Function. Data were analysed using the paired t-test for within-group comparison and the independent samples t-test for between-group comparison.

Results: Both groups demonstrated significant improvement in Fugl-Meyer Assessment scores following the four-week intervention. In Group A, mean scores improved from 21.53 to 40.26 ($t = –10.31$; $p < 0.05$), while in Group B they improved from 23.00 to 26.53 ($t = –2.12$; $p = 0.05$). On post-intervention between-group comparison, the mean Fugl-Meyer Assessment score was significantly higher in Group A (40.26) than in Group B (26.53) ($t = 2.03$; $p < 0.05$). No statistically significant between-group differences were observed for the card turning, stacking checkers, or large light objects subtests of the Jebsen Test of Hand Function.

Conclusion: Knowledge of performance proved to be more effective than knowledge of results when given alongside mirror box therapy in improving hand function in patients with chronic stroke, in terms of Fugl-Meyer Assessment scores. The experimental hypothesis can therefore be partially accepted. Incorporating performance-related augmented feedback into mirror therapy programmes may enhance motor recovery of the upper limb following stroke.

KEYWORDS: Chronic Stroke, Mirror Therapy, Knowledge of Performance, Knowledge of Results, Augmented Feedback, Hand Function, Fugl-Meyer Assessment, Jebsen Test of Hand Function, Neurorehabilitation.

1. INTRODUCTION

Stroke is the leading cause of serious long-term disability in adults, and the high incidence and prevalence of stroke have a major impact on society. More than 60% of stroke survivors suffer from persistent neurological deficits that impair activities of daily living. The paretic upper limb is a common and undesirable consequence of stroke that increases activity limitation. Stroke is defined by the World Health Organization as rapidly developing clinical signs of focal or global disturbance of cerebral function lasting more than 24 hours, unless interrupted by surgery or death, with no apparent cause other than a vascular origin.

The major risk factors for stroke are hypertension, heart disease, and diabetes. Cardiac disorders such as rheumatic valvular heart disease, endocarditis, and cardiac surgery also increase the risk of embolic stroke. Cerebral ischaemia and infarction are usually caused by sudden occlusion of an artery supplying the brain or, less often, by low flow distal to an occluded or highly stenosed artery. Ischaemic events may also result from arterial wall

disorders such as intracranial small vessel disease, trauma, embolism from arterial aneurysms, infections, and haematological disorders.

Treatment of the upper extremity in people with hemiplegia continues to be a challenge, and several methods of exercise therapy for the rehabilitation of stroke patients are commonly used today. Therapeutic interventions such as neurofacilitation techniques, biofeedback, electrical stimulation, robotic-assisted rehabilitation, mental practice with motor imagery, and constraint-induced movement therapy have been used to promote functional recovery.

Mirror therapy, introduced by Ramachandran and Rogers-Ramachandran, is a relatively new therapeutic intervention that focuses on moving the unimpaired limb while watching its mirror reflection superimposed over the unseen impaired limb, thus creating a visual illusion of enhanced movement capability of the impaired limb. Mirror boxes have been used in therapy for stroke and hemiparesis, complex regional pain syndrome, following fractures and brain tumours, and experimentally for the control of pain from a real stimulus. Mirror therapy exploits activation of the mirror neuron system in an attempt to drive nervous system plasticity. It has been shown that the functional organisation of the motor system, including the primary motor cortex, can be modulated by both ipsilateral limb movement and passive observation of movement of the contralateral limb.

Feedback may be either intrinsic or extrinsic. Extrinsic feedback can take the form of knowledge of performance or knowledge of results. Augmented feedback about the nature or quality of the movement pattern produced is termed knowledge of performance, whereas augmented feedback about the end result or overall outcome of the movement is termed knowledge of results. Biofeedback has been used extensively for stroke patients and is a general term describing the use of visual or auditory representation of physiological processes to allow an individual to modify those processes. Previous research evaluating electromyographic biofeedback in the functional recovery of the hemiplegic hand has demonstrated statistically significant improvements in active range of motion and surface electromyographic potentials following treatment.

The present study focuses on combining mirror therapy with augmented feedback in order to examine their effect in patients with chronic stroke. The purpose of this study is therefore to compare the effect of knowledge of performance and knowledge of results when given alongside mirror box therapy in improving hand function in stroke patients.

2. Need of the Study

Mirror therapy has been established as an effective intervention for improving upper limb motor recovery following stroke, and augmented feedback is a well-recognised component of motor learning. However, the relative effectiveness of the two principal forms of extrinsic feedback, namely knowledge of performance and knowledge of results, when delivered alongside mirror therapy has not been adequately investigated. Since the amount of practice and the task can be held identical between the two feedback conditions, any difference in motor performance gains may be attributable to the differing demands on attention and processing capacity imposed by these two types of feedback. Establishing which form of feedback yields superior outcomes may assist clinicians in optimising mirror therapy protocols and improving functional recovery of the hand in patients with chronic stroke.

3. Aim and Objectives

3.1 Statement of the Question

Whether knowledge of performance or knowledge of results is more effective when given alongside mirror box therapy in improving hand function in patients with chronic stroke.

3.2 Aim of the Study

To compare the effect of knowledge of performance and knowledge of results when given alongside mirror box therapy in improving hand function in stroke patients.

3.3 Objectives of the Study

- To evaluate the effect of knowledge of performance combined with mirror box therapy on hand function in patients with chronic stroke.
- To evaluate the effect of knowledge of results combined with mirror box therapy on hand function in patients with chronic stroke.
- To compare pre-intervention and post-intervention hand function scores between the two groups.

3.4 Hypothesis

Experimental Hypothesis: Knowledge of performance would be more effective than knowledge of results when given alongside mirror box therapy in improving hand function in stroke patients.

Alternate Hypothesis: Knowledge of results would be more effective than knowledge of performance when given alongside mirror box therapy in improving hand function in stroke patients.

Null Hypothesis: No effect is seen with either knowledge of results or knowledge of performance when given alongside mirror box therapy in improving hand function in stroke patients.

3.5 Operational Definitions

Stroke: Rapidly developing clinical signs of focal or global disturbance of cerebral function lasting more than 24 hours, unless interrupted by surgery or death, with no apparent cause other than a vascular origin.

Mirror Box Therapy: A therapeutic intervention that focuses on moving the unimpaired limb while watching its mirror reflection superimposed over the unseen impaired limb, thus creating a visual illusion of enhanced movement capability of the impaired limb.

Knowledge of Performance: Augmented feedback about the nature or quality of the movement pattern produced.

Knowledge of Results: Augmented feedback about the end result or overall outcome of the movement.

4. METHODOLOGY

Study Design: An experimental study design with pre-test and post-test assessment was employed to compare the effect of knowledge of performance and knowledge of results when given alongside mirror box therapy in improving hand function in patients with chronic stroke.

Source of Subjects

A sample of convenience was recruited from the department of neurorehabilitation of a tertiary occupational therapy college and hospital.

Sample Size

A total of 30 patients meeting the eligibility criteria were included in the study, with 15 participants allocated to each group.

Study Duration

Participants underwent the intervention for 4 weeks, with sessions conducted 5 days per week.

Variables

Knowledge of performance and knowledge of results were the independent variables. Hand function performance, measured by the Fugl-Meyer Assessment and the Jebsen Test of Hand Function, was the dependent variable.

4.1 Inclusion Criteria

- Patients aged between 50 and 65 years.
- Patients with a first episode of unilateral stroke with hemiparesis during the previous 12 months.
- Patients with no severe cognitive disorders.
- Patients with a Brunnstrom score between stages 1 and 4 for the upper extremity.
- Patients with stroke confined to the territory of the middle cerebral artery.

4.2 Exclusion Criteria

- Patients with previous strokes, major haemorrhagic changes, increased intracranial pressure, or hemicraniectomy.
- Patients with orthopaedic, rheumatological, or other diseases interfering with the ability to sit or move the upper limb.
- Patients with unilateral neglect.
- Patients with apraxia.
- Patients with significant visual impairment or hearing disorder.
- Patients with severe psychiatric disorders such as major depression.

4.3 Method of Selecting and Assigning Subjects to Groups

Participants were randomly allocated into two groups, Group A and Group B, using the chit method. Thirty chits were prepared, with “KP” written on 15 chits for the knowledge of performance group and “KR” written on 15 chits for the knowledge of results group. The folded chits were placed in a box and one chit was drawn by each patient, with the letter noted and the chit not replaced, and the procedure was continued until the thirtieth chit was drawn.

4.4 Outcome Measures

Primary Outcome Measures

- Upper limb score of the Fugl-Meyer Assessment
- Jebsen Test of Hand Function

4.5 Instrumentation and Materials Required

- Mirror box (35 cm × 35 cm)
- Jebsen Test of Hand Function kit
- Chair (18-inch height)
- Table
- Stopwatch
- Pencil and ball

- Assessment forms and stationery

4.6 Procedure

Informed consent was obtained from all subjects and a detailed explanation of the procedure was provided. In Group A, knowledge of performance of the task was given by the therapist while the patient performed hand activities, whereas in Group B, knowledge of results of the task was given. The patients underwent thirty minutes of a mirror therapy programme per day in addition to fifty minutes of a conventional stroke rehabilitation programme, five days a week, for four weeks. The conventional therapy included interventions such as stretching and strengthening, and weight bearing or weight shifting activities.

During the mirror practices, the patient was seated close to a table on which a mirror was placed vertically. The involved hand was placed behind the mirror and the non-involved hand in front of the mirror. The practice consisted of wrist and finger flexion and extension movements, hand opening and closing, forearm pronation and supination, hand sliding on a flat surface, grasp and release, and grasp and shift performed with the non-involved hand while the patient looked into the mirror, watching the image of the non-involved hand and thereby seeing the reflection of the hand movement projected over the involved hand. During the session, the patient was asked to attempt the same movements with the involved hand while moving the non-involved hand. Assessments were performed pre- and post-intervention using the upper limb score of the Fugl-Meyer Assessment and the Jebsen Test of Hand Function.

4.7 Statistical Analysis

Data were analysed using statistical software. The independent samples t-test was used to compare the improvement between the two groups, that is, Group A receiving knowledge of performance and Group B receiving knowledge of results. The paired t-test was used to compare pre- and post-intervention improvement within the respective groups. The level of statistical significance was set at $p < 0.05$.

5. Data Analysis

Table 1.0: Demographic Data of Group A (Knowledge of Performance) and Group B (Knowledge of Results.)

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Age (years)	58.13 ± 3.04	59.20 ± 3.78	0.40 NS
Gender (M : F)	9 : 6	8 : 7	0.72 NS

Table 1.0 presents the demographic data of both groups. The mean age of Group A was 58.13 ± 3.04 years and that of Group B was 59.20 ± 3.78 years, with a p-value of 0.40, indicating no statistically significant difference between the groups. The gender distribution was 9 males to 6 females in Group A and 8 males to 7 females in Group B, with a p-value of 0.72, again indicating no statistically significant difference. The baseline comparability of the two groups with respect to age and gender confirms the homogeneity of the sample prior to the intervention.

Table 2.0: Within-Group Comparison of Fugl-Meyer Assessment and Jebsen Test of Hand Function at Pre- and Post-Intervention.

Parameter	Group	Pre-Intervention (Mean ± SD)	Post-Intervention (Mean ± SD)	t-value	p-value
Fugl-Meyer Assessment	A	21.53 ± 13.21	40.26 ± 15.45	–10.31	0.02*
Fugl-Meyer Assessment	B	23.00 ± 16.15	26.53 ± 21.01	–2.12	0.05*
Card Turning	A	0.00	8.33 ± 22.01	–1.41	0.18 NS
Card Turning	B	0.00	9.26 ± 24.45	–1.46	0.16 NS
Stacking Checkers	A	2.40 ± 5.03	4.33 ± 6.99	–1.09	0.29 NS
Stacking Checkers	B	2.03 ± 5.43	4.75 ± 7.27	–1.60	0.13 NS
Large Light Objects	A	7.02 ± 12.62	3.44 ± 6.60	2.18	0.04*
Large Light Objects	B	8.49 ± 15.79	8.86 ± 14.19	–2.23	0.82 NS

Note: NS = non-significant; * = statistically significant.

Table 2.0 presents the within-group comparison of pre- and post-intervention scores in both groups. In Group A, the mean Fugl-Meyer Assessment score improved from 21.53 ± 13.21 to 40.26 ± 15.45, with a t-value of –10.31 and a p-value of 0.02, indicating a statistically significant improvement. In Group B, the mean Fugl-Meyer Assessment score improved from 23.00 ± 16.15 to 26.53 ± 21.01, with a t-value of –2.12 and a p-value of 0.05, also indicating statistical significance, although the magnitude of improvement was considerably smaller. Among the Jebsen Test of Hand Function subtests, only the large light objects subtest in Group A demonstrated a statistically significant change, while the card turning and stacking checkers subtests did not reach statistical significance in either group.

Table 3.0: Comparison of Pre-Intervention Scores between Group A and Group B.

Parameter	Group	Mean	t-value	p-value
Fugl-Meyer Assessment	A	21.53	–2.70	0.78 NS
Fugl-Meyer Assessment	B	23.00	–	–
Card Turning	A	0.00	–	–
Card Turning	B	0.00	–	–
Stacking Checkers	A	2.40	0.019	0.85 NS
Stacking Checkers	B	2.03	–	–
Large Light Objects	A	7.02	–2.80	0.77 NS
Large Light Objects	B	8.49	–	–

Table 3.0 presents the between-group comparison of pre-intervention scores. None of the parameters demonstrated a statistically significant difference between Group A and Group B prior to the intervention, confirming that both groups were comparable at baseline with respect to Fugl-Meyer Assessment scores and the Jebsen Test of Hand Function subtests. This homogeneity ensures that any post-intervention differences can be more confidently attributed to the effects of the respective feedback conditions.

Table 4.0: Comparison of Post-Intervention Scores between Group A and Group B.

Parameter	Group	Mean	t-value	p-value
Fugl-Meyer Assessment	A	40.26	2.03	0.05*
Fugl-Meyer Assessment	B	26.53	–	–
Card Turning	A	8.33	–0.11	0.91 NS
Card Turning	B	9.26	–	–
Stacking Checkers	A	4.33	–0.16	0.87 NS
Stacking Checkers	B	4.75	–	–
Large Light Objects	A	3.44	–1.34	0.19 NS
Large Light Objects	B	8.86	–	–

Table 4.0 presents the between-group comparison of post-intervention scores. The mean Fugl-Meyer Assessment score was significantly higher in Group A (40.26) than in Group B (26.53), with a t-value of 2.03 and a p-value of 0.05, indicating that the knowledge of performance condition produced a significantly greater improvement in upper limb motor recovery. For the Jebsen Test of Hand Function subtests, no statistically significant differences were observed between the two groups for card turning, stacking checkers, or large light objects.

6. RESULTS

Thirty subjects were recruited for the study, comprising 17 males and 13 females aged between 50 and 65 years, who were randomly divided into two groups with 15 subjects in

each. The mean ages of Group A and Group B were 58.13 ± 3.04 years and 59.20 ± 3.78 years respectively. Baseline comparisons showed that age, gender, Fugl-Meyer Assessment scores, and Jebsen Test of Hand Function scores did not differ significantly between the groups.

In Group A, the mean pre- and post-intervention Fugl-Meyer Assessment scores were 21.53 and 40.26 respectively ($t = –10.31$; $p < 0.05$). Among the Jebsen Test of Hand Function subtests, the pre- and post-intervention means for card turning were 0.00 and 8.33 ($t = –1.41$; $p = 0.18$), for stacking checkers 2.40 and 4.33 ($t = –1.09$; $p = 0.29$), and for large light objects 7.02 and 3.44 ($t = 2.18$; $p < 0.05$).

In Group B, the mean pre- and post-intervention Fugl-Meyer Assessment scores were 23.00 and 26.53 respectively ($t = –2.12$; $p = 0.05$). Among the Jebsen Test of Hand Function subtests, the pre- and post-intervention means for card turning were 0.00 and 9.26 ($t = –1.46$; $p = 0.16$), for stacking checkers 2.03 and 4.75 ($t = –1.60$; $p = 0.13$), and for large light objects 8.49 and 8.86 ($t = –2.23$; $p = 0.82$).

Post-intervention comparison of Fugl-Meyer Assessment scores between Group A and Group B revealed that the mean was significantly higher for Group A at 40.26, compared with 26.53 for Group B ($t = 2.03$; $p < 0.05$). For the Jebsen Test of Hand Function subtests, the post-intervention means between Group A and Group B were 8.33 and 9.26 for card turning ($t = –0.11$; $p = 0.91$), 4.33 and 4.75 for stacking checkers ($t = –0.16$; $p = 0.87$), and 3.44 and 8.86 for large light objects ($t = –1.34$; $p = 0.19$), none of which reached statistical significance.

All patients were unable to perform the writing, picking up small objects, simulated feeding, and moving heavy objects subtests of the Jebsen Test of Hand Function at both pre-intervention and post-intervention assessment.

7. DISCUSSION

This study was designed to investigate the effect of knowledge of performance and knowledge of results when given alongside mirror box therapy in improving hand function in patients with chronic stroke. The Fugl-Meyer Assessment score and the Jebsen Test of Hand Function score were used to assess the improvement in motor performance following both treatment modes. The results suggest that although four weeks of mirror therapy produced significant post-intervention improvements in both groups, Group A performed better than Group B on the Fugl-Meyer Assessment.

Since the amount of practice and the task were identical in both groups, the difference in motor performance gains may be explained by the different demands on attention and

processing capacity required by the two types of feedback. In the knowledge of results condition, the instructions directed the learner's attention to the outcome of their movements, that is, movement precision, regardless of how that outcome was achieved at the behavioural level. In contrast, in the knowledge of performance condition, the instructions directed the learner's attention to the movement patterns themselves and to the adjustments to be made in order to accomplish the task, without emphasising performance outcomes. The benefit of knowledge of performance feedback on movement quality could therefore be attributed to the cognitive effort induced by the feedback, together with better memory, mental flexibility, and planning abilities.

Several underlying mechanisms for the effect of mirror therapy on motor recovery after stroke have been proposed. It has been suggested that the mirror illusion of a normal movement of the affected hand may substitute for decreased proprioceptive information, thereby helping to recruit the premotor cortex and assisting rehabilitation through an intimate connection between visual input and premotor areas. Another possible mechanism is the involvement of the mirror neuron system, as movement observation has been shown to modulate not only motor cortex excitability but also cortical somatosensory representation.

Previous research supports these findings. A study conducted on 40 chronic stroke patients randomly assigned to a mirror group or a control group for a six-week training programme found that mirror therapy was significantly more effective on Fugl-Meyer Assessment scores than the control condition, and correlated this with functional magnetic resonance imaging results showing a shift in activation balance within the primary motor cortex towards the affected hemisphere in the mirror group. Transcranial magnetic stimulation performed during mirror illusions in healthy subjects has shown increased excitability of the primary motor cortex of the hand behind the mirror. Further research has concluded that functional reorganisation occurs in patients with primary motor cortex injury, and that primary sensorimotor cortical activation shifts significantly from the unaffected to the affected hemisphere in chronic stroke patients.

For the Jebsen Test of Hand Function subtests, the post-intervention mean for large light objects in Group A was better, which may be attributable to relatively greater proximal muscle control and to the fact that these activities do not require skilful distal movement. Patients were unable to perform the writing, picking up small common objects, simulated feeding, and moving large heavy objects subtests, since these tests rely predominantly on skilful control of distal hand function and on greater proximal arm control combined with strength respectively. This may explain the absence of statistically significant between-group

differences on the Jebsen Test of Hand Function subtests despite the significant difference observed on the Fugl-Meyer Assessment.

8. CONCLUSION

From the results of the present study, it can be concluded that knowledge of performance proved to be more effective than knowledge of results when given alongside mirror box therapy in improving hand function in patients with chronic stroke, in terms of Fugl-Meyer Assessment scores. The experimental hypothesis can therefore be partially accepted. Although both feedback conditions produced significant within-group improvement following four weeks of mirror therapy, the performance-related feedback condition yielded a significantly greater improvement in upper limb motor recovery. Incorporating knowledge of performance into mirror therapy programmes may therefore enhance functional recovery of the hand in patients with chronic stroke.

LIMITATIONS

- The study population was small.
- No imaging techniques were used that might have demonstrated brain reorganisation following therapy.
- There was an absence of long-term follow-up.

Scope for Future Study

- To determine the effect of mirror therapy when combined with electrical stimulation.
- To compare the effect of mirror therapy and constraint-induced movement therapy in stroke patients.
- To determine the effect of knowledge of performance and knowledge of results using hand activities such as clapping, or other activities incorporating auditory feedback, when given alongside mirror therapy in stroke patients.

Conflicts of Interest: None.

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