



Original Article

Motor image recall ability affects the excitability of spinal nerve function in healthy participants executing mirror therapy tasks at different complexities

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Abstract. [Purpose] The purpose of this study was to use Mirror Therapy to clarify the effect of the differences in image recall ability and the types of finger exercises on the excitability of spinal nerve function. This study will help establish the methodology for therapeutic intervention using Mirror Therapy. [Participants and Methods] We divided 30 healthy right-handed adults into two groups: one with high exercise image recall ability and the other with low exercise image recall ability. The participants were asked to put both hands in the Mirror Box such that the left hand was hidden behind the mirror. While looking at the mirror image of the right hand, they were instructed not to move the left hand voluntarily. We measured the F-wave from the finger abductor muscle using evoked electromyography. [Results] The comparison between the high and low image recall groups showed that the excitability of spinal nerve function increased in the low image recall group overall. [Conclusion] From the above results, we suggest that when performing mirror therapy, it is necessary to select a task that is not too simple and not difficult to move normally.

Key words: Mirror Therapy, Spinal nerve function, F wave

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INTRODUCTION

In recent years, attention in the field of rehabilitation and sports has been focused on motor images, and various methods have been used as treatment interventions for stroke patients. It is important to clearly understand how the motor image can imagine a movement.

Visual illusion with a mirror is a method that is used to form a clear and real motor image and assist the patient's movement representation in a rehabilitation scene. One method is the Mirror Therapy—a method devised by Ramachandran et al.¹⁾ which uses a superimposed mirror image of the non-paralyzed limb on the position of the paralyzed limb, to induce an illusion of the paralyzed limb's movement.

Mirror Therapy uses the movement of the hand in the mirror to give the patient a visual image of the correct movement, and the illusion produces a sense of motion, leading to activation of the premotor and motor areas. Furthermore, it is a treatment method that aims to remove the phantom pain and improve stroke-caused hemiplegia by influencing the reconstruction of the body image in the somatosensory area. It is achieved by placing a mirror as a screen in the middle of a box that is large enough for both arms to enter, then, the arm is put in the box such that the hand without paralysis is reflected in the mirror. When the hand is moved in that state, a visual illusion effect is reflected in the mirror as if both arms are moving symmetrically. Since this report, various researchers have reported the effect of Mirror Therapy on motor paralysis in randomized control trials (RCT) involving hemiplegic stroke patients^{2–6)}. However, further investigation of the methodology such as

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effective treatment intervention time and what kind of hand movement is more effective is required. A study of the effect of Mirror Therapy from the aspect of brain activity reported activation of the movement area⁷⁻⁹), but there is no controlled clinical research and there is no report about the influence on spinal nerve function.

The purpose of this study was to use Mirror Therapy to clarify the effect of the difference in image recall ability, and the types of finger exercises on the excitability of the spinal nerve function. This will help establish the methodology for therapeutic intervention using Mirror Therapy.

PARTICIPANTS AND METHODS

The participants for this study were 30 healthy adults (mean age: 25.17 ± 6.76). Exclusion from the study were those who did not consent to participate in this study and those who complained strongly of pain during F-wave measurement. We used the Edinburgh handedness Inventory¹⁰) to confirmed that all participants were right-handed before the measurements started. The participants were given written and advanced explanations of the purpose and method of this research and the handling of personal information. Written informed consent was obtained after the contents of the explanation have been well understood. This study was conducted with the approval (approval number 13-26) of the ethics committee of Kibi International University of which I belong to.

We used the Movement Imagery Questionnaire (MIQ) created by Hall & Pongrac¹¹) to measure motor image recall ability. We also used the Kinesthetic Imagery Scale (1: Very hard to feel, 2: Hard to feel, 3: Somewhat hard to feel, 4: Neutral, 5: Somewhat easy to feel, 6: easy to feel, 7: Very easy to feel), which is the evaluation scale used in the modified version of Movement Imagery Questionnaire-revised (MIQ-R)¹²) to evaluate, in advance, how clearly the participants recalled the image. The motor image task at that time was confirmed using the Kinesthetic Imagery Scale. This was after an opposing movement-image of a pinch movement of putting and releasing the left thumb and index finger at a speed of 1 Hz with eyes closed for 1 minute had been performed. A score of 1–3 was considered low image recall ability while a score of 5–7 was considered high image recall ability. Results from these processes were used to divide the participants into two groups; one with high motor image recall ability and the other with low motor image recall ability.

At this stage of the experiment, the participants were instructed to put both hands in the mirror box such that the left hand is hidden. They were then asked to look at the right hand in the mirror, with the left hand remaining unmoved voluntarily (Fig. 1).

Three different right-handed fingers performed a set and release opposing motion at a frequency of 1 Hz. An F-wave was measured by electromyography.

The following three types of tasks shown in Table 1 were used. All task movements in the right hand were at a frequency of 1 Hz, while the eyes looked at the hand in the mirror. Three types of tasks were performed at random, with a 5-minute break between tasks.

The participants were in a sitting position, and slight flexion of the elbow joint was made with forearm supination on the desk in the front, and F-wave was measured by the “belly tendon” method from the minor abductor muscle of the left hand behind the mirror (Fig. 2). The measuring instrument used was electromyography MEB-9402 manufactured by Nihon Kohden Co., Ltd.



Fig. 1. Using mirror box.

The participants were instructed to put both hands in the mirror box such that the left hand is hidden. They were then asked to look at the right hand in the mirror, with the left hand remaining unmoved voluntarily.

Table 1. Three types of tasks

Task 1	Repeat the opposing movement of thumb and index finger.
Task 2	Repeat the opposing movement of thumb and the other finger of the right hand (index finger, middle finger , ring finger , little finger in order).
Task 3	Repeat the opposing movement of thumb and the other finger of the right hand (index finger, ring finger , middle finger , little finger in order).

The F-wave was maximally stimulated on the median nerve at the wrist joint area according to Kimura's method¹³, and the F-wave was derived from the right short thumb abductor muscle by the Berry tendon method. The stimulation interval was 1 Hz and 16 consecutive recordings were made. The bandpass was 1 Hz to 3 kHz. Then, the average amplitude of the F-wave obtained by 16 times of stimulation was determined, and the amplitude ratio to the M-wave recorded simultaneously was calculated. The value of the F/M amplitude ratio was used for analysis. For statistical analysis, the Mann-Whitney U test was used to compare the two high and low image recalling groups in each task.

RESULTS

The median of 4 was recorded from the Kinesthetic Imagery Scale of image recall ability test performed in advance. Twelve participants had low image recall ability while 12 other participants had high image recall ability. The result of the average F/M amplitude ratio for each motion task of the right hand by the difference of the image recall ability is shown in Table 2 below.

There was increased excitability of the spinal nerve function in the low image recall group as a whole compared to the high image recall groups according to each task (Task 1: $p=0.259$, Task 2: $p=0.048$, Task 3: $p=0.213$). Task 2, with the thumb and the other finger of the right hand (in order of the index finger, middle finger, ring finger and little finger), was the only task that showed a significant difference in the excitability of the spinal nerve function after repeating the opposing movement.

DISCUSSION

In the F-wave, when the maximum electrical stimulation is applied to the motor nerve, all the motor nerves fire, and anterograde and retrograde impulse conduction in the axon occur simultaneously. And in spite of the normal refractory period, in some spinal anterior horn cells, re-ignition with axon-hillock generates antegrade action potentials for retrograde impulses and causes conduction to muscles. This is recorded as a compound muscle action potential. The waveform of the F-wave is characterized by being different for each stimulation, and its amplitude is said to reflect the excitability of spinal nerve function¹⁴.

In Nomura et al.'s previous research¹⁵, when imaging three types of tasks that are similar to this research, it was reported that excitability increased in the group with low clarity of the motor image increased for each of Task 1, Task 2, and Task 3. In contrast, the excitability of Thenar muscles's spinal motor neuron function did not increase in the group with high clarity of the motor image for each of Task 1, Task 2, and Task 3. Also, in this study, the excitability of the spinal nerve function was confirmed in the group with low image recall ability compared with the group with higher image recall. However, only Task 2 was statistically significant. Even in the case of Maeda et al.'s report¹⁶, when the same three types of tasks were imaged, Task 2 was significantly more excited than Task 1 and motor images with high complexity like Task 3 had difficulty in recalling the image itself, hence, excitability did not change in Task 3. In Maeda et al.'s research, the image of the hand movement was recalled and repeated, but in this research, the same result was obtained only by looking at the hand reflected in the mirror, not the image of the movement. It became clear from this result that looking at the hand reflected in the mirror created a visual illusion and increased the excitability of the spinal nerve function of the left hand that was not moving. It also became clear that movement with high complexity like Task 3 cannot get the same effect of illusion. In this case, it may be difficult to recall the image itself, or for people with high image recall ability, they may recognize that the hand in the mirror is not their left hand, thus, making it difficult to obtain the illusion effect in the mirror. Consequently, it is thought that the excitability of the spinal nerve function is unlikely to increase. From the above findings, we suggest that it is necessary to select a task that is

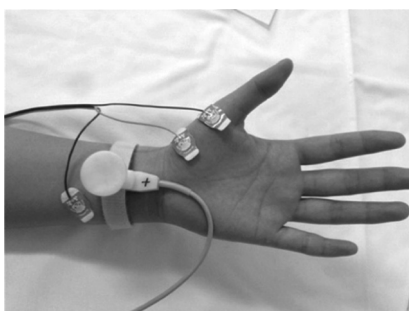


Fig. 2. Electrode attachment (Berry tendon method).

The exploring electrode was placed over the belly of the right abductor pollicis brevis muscle, the reference electrode on the proximal phalanx of the thumb, and the ground electrode on the forearm.

Table 2. Results of amplitude F/M ratio for each task

	High image recall group	Low image recall group
Task 1	1.850 ± 0.532	2.142 ± 0.684
Task 2	1.925 ± 0.631	2.517 ± 0.646 *
Task 3	2.092 ± 0.423	2.483 ± 0.740

* $p<0.05$ (vs. Task 2 High image recall group).

not too simple and not too difficult to move normally when performing mirror therapy.

The adjustment of the task difficulty level was very important. Nishida et al.¹⁷⁾ reported that various factors are involved in the effect of the Motor image and that the Motor image can be divided into two. One is the “intelligibility”: how the learner can consciously recall clear images of the task, and the second is the “controllability”: how to convert the recalled images into operations. In this study, we evaluated “intelligibility” and grouped it, but Mirror Therapy is a tool to see the hand in the mirror and give an illusion and to enable us test controllability (how the image can be controlled into operations). Evaluation of controllability is thus, required in the future.

The limitations of this study are the results from healthy adult participants, and are not data from actual patients. In paralysis limbs of stroke, the chance of receiving visual feedback that moves as expected due to the effects of motor paralysis is drastically reduced, and the motor image is thought to deteriorate. Therefore, it is important to increase the difficulty little by little, starting with a simple hand movement task, using mirror therapy to create a visual illusion. In the future, we would like to measure data from actual stroke patients and use it as an index to provide the rehabilitation that is necessary in clinical practice.

Conflict of interest

There is no conflict of interest to be disclosed in this research.

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