A Study of Evaluation Methods on Effects of Horticultural Therapy in Recovery Stage Rehabilitation

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Abstract

Horticultural therapy (HT) is gaining recognition, especially in the fields of physical therapy, occupational therapy, and nursing, although there is little existing research supporting the benefits of HT. This paper assesses the effect of HT on brain injured patients by measuring functional brain activity using functional magnetic resonance imaging (fMRI) and functional independence measure (FIM) and corroborates that with recorded observations of a team comprised of a registered horticultural therapist (HTR), a certified therapeutic recreation specialist (CTRS), and medical doctors specialized in rehabilitation and brain function. Five patients with cerebro-vascular accident (CVA) were invited to participate in HT twice a week for a month in addition to their regular routine physical and occupational therapy. Some improvement was shown in FIM results in mobility and social interaction. The visual cortex, parietal lobe, and frontal cortex of fMRI examinations became the focus points to see the brain function, and normal brain activity for the task was seen in the results. Analyzing fMRI results requires specialized expertise. These numeric methods to measure changes of the human body and mind can be used as supporting evidence, but systematic record of observation would be the best evaluation method of therapies and rehabilitations.

Introduction

The concept of horticultural therapy (HT) was introduced to Japan in the 1990s and further supported by the formation of the Japanese Horticultural Therapy Association (JHTA) in 2008. However, HT is just recently gaining recognition, especially in the fields of physical therapy, occupational therapy, and nursing.

Although many advocate HT, there is little existing research supporting the benefits of HT. This may be due in part to the diversity of professionals practicing HT as evidenced by the JHTA's membership which includes medical doctors, nurses, occupational therapists, psychiatric social workers, welfare professionals, and horticultural therapists. This has made it difficult to establish both an agreed-upon definition of HT and an accepted method of evaluation.

Since both JHTA and its parent organization, Japanese Society of People-Plant Relationships started to publish journals, the effects of HT were discussed using physiological and psychological measurement tools. Furuhashi (2006) tried to measure the effects of horticultural activity on healthy gardeners, using heart rate, body temperature, brain waves, and Profile of Mood States (POMS), but no significant correlations between those measurements and POMS were observed. Another group studied the effect of a HT program at a psychiatric hospital using the State-Trait Anxiety Inventory (STAI) and Salivary Chromogranin A (CgA) (Fujioka et al., 2009), but could not attribute the effects to the horticultural activity because other factors affected the results too much.

In the United States, Ulrich (1984) looked at the effect

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of the natural environment by studying the positive influence of nature on the recovery of surgery patients in a hospital by comparing the number of days stayed after surgery, amount and type of painkillers used, and number of negative comments by nurses. Ulrich et al. (1991) showed reduction of the emotional, attentional, and physiological aspects of stress using Zuckerman Inventory of Personal Reactions (ZIPERS) to assess feelings, and electrocardiogram (ECG), pulse transit time, galvanic skin response and frontalis muscle tension as well as blood pressure to measure physiological reactions. However, most of the studies used questionnaires for measuring the effect of HT, except for Test for Severe Impairment (TSI) which measured the cognitive level of dementia patients (D'Andrea et al., 2008), and electroencephalograms (EEG), electrodermal activity (EDA) and skin temperature to measure physiological responses of healthy university students (Liu at el., 2003).

The purpose of this study was to assess the effect of HT on brain injured patients by measuring brain activity using functional magnetic resonance imaging (fMRI) and functional independence measure (FIM) which were then compared to the therapists' recorded observations. The therapists in this study consisted of a registered horticultural therapist and a certified therapeutic recreation specialist (CTRS). These therapists were teamed with medical doctors specialized in rehabilitation and brain function. Together they designed experimental fMRI protocols that revealed visual, cognitive, motor, and emotional functions/abilities (Mizuno-M et al., 2008). The therapists designed the HT program (see below), which was added to each patient's medical and physical treatment routine. Both fMRI and FIM were measured before and after a month-long HT program.

Method

Five patients who had a similar level of condition and recovery from their brain injuries, but demonstrated decreased interest in their routine rehabilitation programs, were chosen from in-patients. Those subjects were from 42 to 75 years of age at the time of the study, and their conditions are introduced in Table 1. All of them were informed of the experimental purposes and protocol in detail, and signed written informed consents.

Each patient attended HT sessions conducted by horticultural therapists. Before and after one month starting the HT program, FIM was scored by the attending caretaker for each patient, and fMRI was given to all subjects. Both FIM and fMRI were processed to analyzable data, respectively.

HT Program

Horticultural activity sessions were added twice a week for one month to regular routine physical and occupational therapy. The whole program is as Table 2, but the order and progress varied with individual patients depending on their ability, willingness, emotional state, or simply on weather. Each patient was observed by his/her own therapist and the results of observation were recorded.

FIM (motor & cognitive)

FIM was used to determine the level of each patient's physical and mental function at the institution. It is an assessment instrument rating a patient's level of function in 18 tasks (13 motor items and 5 cognitive items) that represent the basic activities of daily living (ADL). The total score ranges between 18 as perfect dependence to 126 as perfect independence. Scores were taken from each patient in advance and afterwards of the period that the patients participated in the HT program.

Table 1. Conditions of the subjects and patients.

Age/Sex	Case 1 75/M	Case 2 42/M	Case 3 60/F	Case 4 56/M	Case 5 68/F
Diagnosis	Right internal carotid artery occlusion	Left hemiplegia and dysarthria	Right anterior cerebral artery occlusion	Right thalamic bleeding	Bleeding in the right frontal lobe
Paralysis／Disabilities	Left hemiplegia ／dysarthria, attentional deficit	Right hemiplegia ／aphasia, hyperplesia, mild depression	Left hemiplegia	Left hemiplegia	Left hemiplegia ／dysarthria

Table 2. Horticultural therapy programs.

Activity	Description/ remarks	
1. Preparation of flower beds	From weeding, soil making, to flower bed making	Outdoor/ indoor
2. Planting design and plan	Using books and color pencils, design the flower bed	Indoor
3. Seed selection	Select seeds, according to the color, height and season of design plan.	Indoor/ outdoor
4. Seeding to flower beds	Seed the flowerbeds according to plan.	Outdoor
5. Taking care of flower beds	Watering, weeding, picking up unnecessary leaves and flowers, and harvesting (if possible).	Outdoor
6. Mixed pot making	This is a program for rainy days, or for person who does not want to work with other people.	Indoor/ outdoor
7. Craft	This is a program for rainy days.	Indoor
8. Container garden making	This program is for encouraging patients to continue horticulture after returning home. They can take their container home.	Indoor/ outdoor

fMRI

fMRI is a kind of magnetic resonance imaging (MRI) scan using blood-oxygen-level dependent (BOLD) signals to find activity areas of brain functions by task. When nerve cells of the brain become active, it increases oxygen consumption, leading to rapid anaerobic glycolysis. This activity increases blood flow to regions of neural activity after a few seconds delay. This response comes to its peak for 4 to 5 sec, and then falls back to normal condition. Oxygen to supply the high consumption area is transported by hemoglobin. Oxygen-bound hemoglobin is called oxyhemoglobin, which is diamagnetic, and hemoglobin without bounding oxygen is called deoxyhemoglobin, which is paramagnetic. MRI scan captures deoxyhemoglobin under this process to show the region (function) where nerve cells are active. This is how fMRI works.

However, in order to activate nerve cells of the brain, subjects need to be given a task related to the purpose of the experiment. In this case, recognition tasks to clarify viewing, recognition, movement, and emotional functions/abilities of subjective patients were designed.

Each subject lay on the table of the MRI scan device, in which he/she fixated on images shown in front of his/her face. Each subject was instructed to send signals by wiggling the index finger of each hand; for "pleasant" picture on the right and "unpleasant" picture on the left. Two photos were used in random order in this task; a picture of a girl with a smile and a picture of the same girl with a sad face. Each picture was shown for 2 seconds followed by a white screen with a plus sign in the center for 20 to 30 sec and this was repeated 20 times (Figure 1).

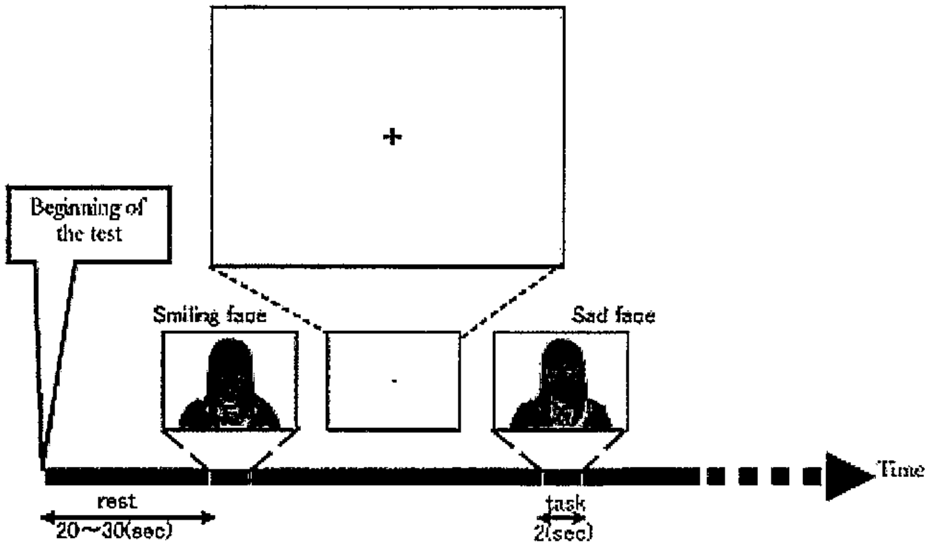


Figure 1. Flow of task for fMRI scan.

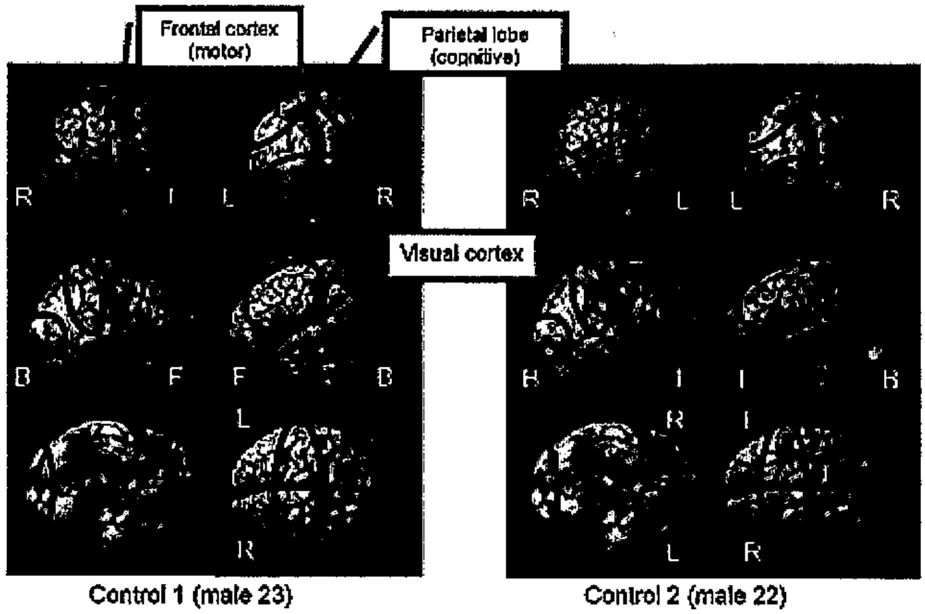


Figure 2. Images of activated areas.

MRI scanner was activated during this task to measure brain activity.

Images were acquired on a 1.5 Tesla SIGNA CV/I scanner (GE Medical Systems, Milwaukee, WI). After initial acquisition of T1 structural images, echo planar imaging (EPI) was used to obtain data sensitive to the BOLD signal at a repetition time (RT) of 2000 milliseconds (ms) and an echo time (TE) of 40 ms. High-resolution T1 images were acquired to aid in anatomic normalization. The spatial resolution of BOLD images was set by a 64 by 64 voxel matrix covering 260 x 260 mm^2 with a 5 mm slice thickness. The image gave an in-place resolution of 4.06 by 4.06 mm². Twenty axial slices with 5 mm thickness were acquired to cover the whole brain. During the data acquisition, 258 images (phases) per slice were obtained in 51.6 sec (= 258 x 0.2 sec). This produced a 4-D dataset consisting of 64x 64 x 20 x 258 voxels, in which a voxel is referred to as (x, y, z, t).

Statistical Parametric Mapping analytic package (SPM5, the Wellcome Trust Center of Neuroimaging, London, UK) was used to analyze the data. For the first step, regions that showed significant activation during the pleasant or unpleasant images compared to the white screen with plus sign were identified for both before and after participating in the HT program course.

For the results of fMRI, two healthy young males performed the same task to measure the brain activity as control samples to see which part of the brain is activated by this task. As Figure 2 shows, the areas which represent visual (visual cortex), cognitional (parietal lobe), and motor and emotional (frontal cortex) became active, as the task design intended. Therefore the same area as the above would be compared on the results of fMRI of subjective patients before and after participating in the HT program.

Results and Discussion

The results of observations by the therapists, and FIM

Table 3. Results of observation and FIM.

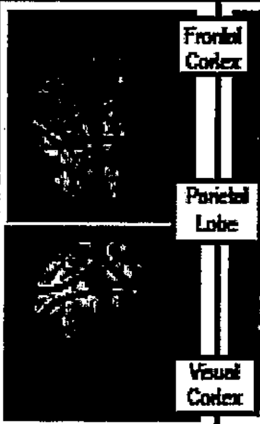
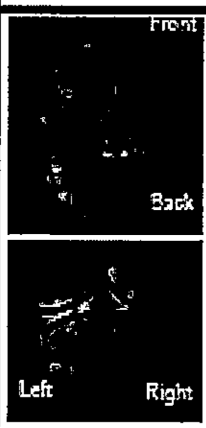
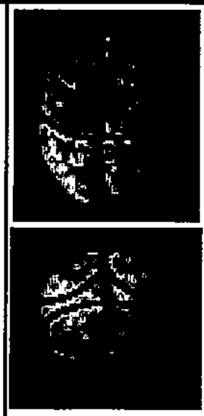
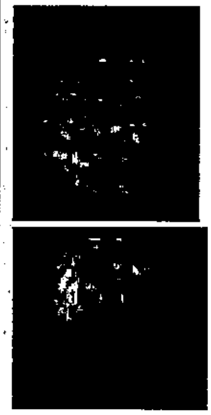
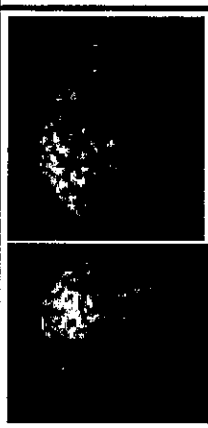
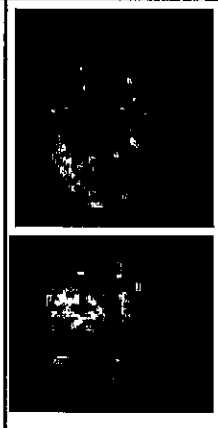
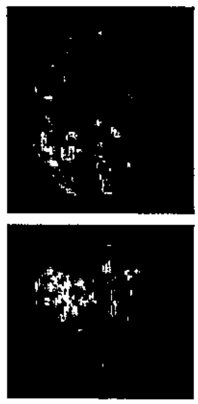
Age/Sex	Case 1 75/M	Case 2 42/M	Case 3 60/F	Case 4 56/M	Case 5 68/F
Remarks	Hard to accept own disabilities. Always enjoyed horticulture Wife is very understanding	Hard to accept own disabilities and suffers from mild depression Has no interest and is negative to horticulture Over-weight from lack of exercising. Used to work as an illustrator. Introverted personality	Likes to flowers although has no experience in horticulture Looks disturbed during session and cannot keep up the pace. Likes making craft which can be shown to other people Passive stand for outdoor activities	Passive stand, but does not like to lean on other people. Has interest in horticulture, but believes he cannot start new thing.	Outgoing and talkative, but cannot speak well because of her disability. Hard to accept own disabilities. Has anxiety for life after discharged from hospital. Has interest in horticulture.
Obser-vation	Stabilize standing position Able to reach-out for work at raised-bed. Too active so that he had to be cautious not to fall.	Seen improvement in weeding using left hand. Constructing images during work. Showed more smile as program progressed. Watering and observing of plants voluntarily.	Always uneasy and anxious while doing rehabilitation with occupational therapist, but she was absorbed in horticultural activities. Activities like the one using scissors became a good rehabilitation for elaborate-ness.	At first, engagement to horticultural activity was result of encouragement. After a while, he participated the work more actively and stood up from his wheelchair more smoothly. Started to go outside willingly. As he could complete more things he smiled more.	At first, cautiously nursing paralysis side of the body while doing horticultural activities. After able to confirm disability would not stop participation in the activities, started to do more actively. Told horticulture would be an encouragement for the life after returning home.
FIM	62 -> 92 ↑	91 -> 89 ↘	86 -> 116 ↑	64 -> 114 ↑	59 -> 104 ↑
(Motor)	38 -> 68 ↑	72 -> 71 →	53 -> 81 ↑	39 -> 85 ↑	33 -> 75 ↑
(Cognitive)	24 -> 24 →	19 -> 18 →	33 -> 35 ↗	25 -> 29 ↗	26 -> 29 ↗

Note: Tilting arrow shows slight change in values.

scores are put together in Table 3. From the observations of therapists, all five patients have shown positivism and improvement in mobility and social interaction. The results of FIM back up these improvements; overall, and motor score for FIM improved in case 1, 3, 4 and 5, and for case 2 the score of FIM was relatively high for his ability from the beginning so that the score showed no improvement.

From the experiment of the control samples, the visual cortex, parietal lobe, and frontal cortex became the focus points to see the brain function of subjective patients. In order to make it easier to compare and understand the

Table 4. Results of fMRI.

		Case 1	Case 2	Case 3	Case 4	Case 5
Age/Sex		75/M	42/M	60/F	56/M	68/F
Paralysis/ Disabilities		Left hemiplegia/ dysarthria, attentional deficit	Right hemiplegia/ aphasia, hyperpiesia, mild depression	Left hemiplegia	Left hemiplegia	Left hemiplegia/ dysarthria
Picture of fMRI	Top view Before HT Back view					
	After HT					
Points of recognition task	visual	Recognize distance by vision	Liked image making of garden	Progress in flower arrangement with colors	Recognizing people he knows well	
	cognitional	Recognize distance and reach out arms	Work according to the image plan Smiles more at people he knows well.	Understands the process of activity and concentration	Smiles more at people he knows well	Reaches acceptance of own disability
	motor	Standup position became more stable	Fine-work by left hand was improved	Use of scissors was improved.	Standup position became more stable.	Use remaining ability better than before.
	emotional	More positivism	Smiles more. More positivism	More communication through own work	Make more smile More positivism	Positive attitude towards the date of release from the hospital.

Source of brain activity images: Horticultural therapy has beneficial effects on brain functions in cerebrovascular diseases. International (Mizuno-M et al. 2008).

activated area of fMRI pictures, only top view and back view of the pictures of each patient are used in this study This is because the common order to show six-views of a brain is not easy to understand or reconstruct into a three dimensional image by people who are not familiar with the pictures.

Table 4 shows the results of fMRI before and after the HT program along with the observations relevant to these three areas. It is very difficult to see the results of fMRI from the pictures, however, from the viewpoint of a brain function specialist, the pictures showed normal brain activity for the task.

Cases 1, 2 and 5 showed more activities in the visual cortex after the HT program, and case 3 showed strong activity both before and after the HT program. Patients who suffered brain-damage usually show less activity in the visual cortex when they are doing only routine rehabilitation, so the result might tell us the effect of the HT program on the subjective patients. From observation, patients showed improvements in the most relevant task areas. As shown in Table 3, patients have differences in points of interest, experience with flowers or in horticulture, life-style before brain-damage, and family members who are most supportive.

In this study, FIM and fMRI are used as a tool to measure the effect of HT on patients, however, changes in the score of FIM and the area activated in fMRI only tell that the therapeutic program is working, but not how it works on each patient. How the program works can be obtained only by observation by therapists, which means that the tool to evaluate and record the effect is therapists. In order to make subjective observations more objective, observation of a patient must be done by one therapist for the whole program, in other words, one-on-one therapy gives the best results in recording.

Using the objective numerical tools to measure physiological and psychological changes of patients for corroboration, subjective observation records can be a good material for assessing patients to plan goals for further improvement for a patient.

The effects of therapies such as HT are very difficult to measure numerically. In this study, fMRI was used for assessing improvement of patients who lost the willingness to their routine rehabilitation program to evaluate its usefulness. Unfortunately, it was very difficult to analyze the results of fMRI without a brain function specialist, so fMRI might not be a practical tool for measuring the effect of HT on a regular basis. However, using these scientific methods to measure changes of the human body and mind as supporting evidence, the systematic observation record would be the best evaluation method of therapies and rehabilitations. We would like to continue studying the best method to record results in systematic order and to find the best way to assess the effect of HT.

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