Title: Non-invasive Brain Stimulation and Prism Adaptation in Art Constructive Errors of Painting

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Abstract:

**Introduction:** This study aimed to investigate the influence of neglect and the effect of Prism Adaptation (PA) combined with continuous Theta-Burst Transcranial Magnetic Stimulation (cTBS) on the art constructive errors of painting rehabilitation of stroke patients with neglect.

**Methods:** Fourteen patients with neglect and art constructive errors of painting secondary to stroke were randomly assigned to the rehabilitation group and received PA combined with inhibitory protocol of cTBS over the intact parietal cortex; the control group received PA combined with sham cTBS for 2 weeks in 10 daily sessions. Patients have assessed for art constructive errors of painting in Figure Copying Test (FCT), and Coloring Test (CT) before and after the intervention. Art constructive errors of painting were classified into omission, deformation, size, neglect of warm colors, and perseveration of errors. Neglect was evaluated using the Line Bisection task (LBT), Figure Copying Test (FCT), and Coloring Test (CT).

**Results:** All patients showed significant improvement in art constructive errors of painting (measured using pattern of painting’ errors in Figure Copying Test and Coloring Test), and neglect (measured using LBT, FCT, and CT) ($p<0.05$). Omission, neglect of warm colors, and deformation were the most frequent errors.

**Conclusion:** Neglect and rehabilitation influences the painting system in stroke patients. Both approaches improved art constructive errors of painting and neglect symptoms.

**Keywords:** Rehabilitation, Neglect, Painting, Coloring, Prism, Brain Stimulation
Highlights

- Both therapeutic approaches (cTBS+ PA and PA) showed significant implicit recovery in art constructive errors of painting and neglect without practice.

- Visuospatial unilateral spatial neglect appears to specifically affect the art system of patients with stroke.

- Art constructive errors of painting patterns were an omission, deformation, size discrepancy, neglect of warm colors, and perseveration.

Plain Language Summary

Art is a human communication tool. However, there is limited research into therapy for adults with acquired art constructive errors of painting in stroke patients. Nevertheless, no study to date has examined the relation between art-specific constructive errors of painting and spatial neglect and rehabilitation without painting practice. The present study detected the pattern of art constructive errors of painting in before intervention and investigated rehabilitation with prism adaption alone and prism adaption combined with continuous Theta-Burst Transcranial Magnetic Stimulation to treat art constructive errors of painting in patients with neglect.
Introduction

Injury to the right hemisphere of the brain often associated with the neurological disability of function and neglect-induced cognitive impairment in drawing, coloring, and copying is known as art constructive errors of painting (Rhee, Hong, Kim, & Lee, 2016; Rode, Pagliari, Huchon, Rossetti, & Pisella, 2017). Art constructive errors are among the spatial disorders of painting and commonly include missing elements, omission errors, and change in size error, visuospatial destruction mistake, and neglect of warm colors fault. These errors have been observed in patients, such as professional artists, with damage to the right brain stroke (J.-M. Annoni, G. Devuyst, A. Carota, L. Bruggimann, & J. Bogousslavsky, 2005; H. Bätzner & M. G. Hennerici, 2007). Particularly, right-brain stroke-related disturbance of painting demonstrates various forms associated with the distinctive painting system of a given art. For example, some professional painters had difficulty in painting in terms of deformation figures, disruption in landscapes, and disruption in estimate of depth and distance (J. Annoni, G. Devuyst, A. Carota, L. Bruggimann, & J. Bogousslavsky, 2005; H. Bätzner & M. G. Hennerici, 2007; Chen et al., 2016; Mazzucchi, Sinforniani, & Boller, 2013; Pasqualini & Isabella). However, these art constructive errors of painting are not quite understood. The errors may be affected by visuospatial processing, have a convened array of art constructive errors of painting, and require a particular rehabilitation strategy of their art constructive errors systems (H. Bätzner & M. G. Hennerici, 2007; Vaes et al., 2018; Vallar, Zilli, Gandola, & Bottini, 2006). Currently, clinicians have several options to consider when choosing interventions for those living with a deficit in visuospatial processing and unilateral neglect, including mirror therapy, prism adaption (PA), and non-invasive brain stimulation (Azouvi, Jacquin-Courtois, & Luaute, 2017). Prism intervention is a visuospatial processing rehabilitation that has been shown to have a promising therapeutic effect on multiple aspects of visuospatial neglect, motor-related symptoms of spatial neglect, as well as the performance of activities (Hreha, Gillen, Noce, & Nilsen, 2018). Non-invasive brain stimulation, Transcranial Magnetic Stimulation (TMS) is another approach treatment that has been effective in visuospatial unilateral neglect recovery. At least one study showed higher efficacy of continuous Theta-Burst Transcranial Magnetic Stimulation (cTBS) compared to other patterns of TMS (Cazzoli et al., 2012; Cotoi, Mirkowski, Iruthayarajah, Anderson, & Teasell, 2019; Yang et al., 2015). Therefore, there is a need for more effective approaches for stroke rehabilitation, for example, the use of a combination of strategies of PA combined with cTBS. However, the effect of PA+ cTBS has not
been studied on changes in specific art constructive errors of painting and visuospatial unilateral neglect.

Accordingly, patterns in art constructive errors of painting were detected to improve pattern in error of painting. In this study has examined the relationship between art constructive errors of painting and neglect in stroke patients before and after rehabilitation. We hypothesized that cTBS would increase prism adaption effects on improving art constructive errors of painting, and visuospatial unilateral neglect test score.

**Material and methods**

This pilot study was conducted in Shariati Hospital, Tehran University of Medical Sciences, Iran, from August 2017 to November 2018.

**Subjects**

Fourteen individuals enrolled for rehabilitation in neglect and art constructive errors of painting. Stroke patients with neglect and art constructive errors of painting, verified by MRIs, clinical examination and paper-pencil evaluation (the Line Bisection task, Figure copying Test, and Coloring Test), were enrolled and provided informed consent for participation. Total 14 patients with neglect and art constructive errors of painting secondary to stroke were randomized via block randomization method assigned to 2 groups for rehabilitation. They were tested for art constructive errors of painting using Figure copying Test, and Coloring Test. They were also asked to attend 10 sessions over a 2-week period of rehabilitation with prism adaption (Ten Brink, Visser- Meily, & Nijboer, 2015) combined with non-invasive brain stimulation. The prism glasses with 10 degrees of the visual field displacement with adaptation by mirror training was given to the participant. Stroke patients was placed sat near a table on which a vertical mirror box (35*35* 35 cm). They observed the reflection of the right intact hand as the movement of the left hand in the mirror for 20 minutes (Ng, Pandian, Singh, Arora, & Kaur, 2015). In addition to prism adaption, one group of stroke patients received continuous theta burst stimulation over the left parietal (P3) cortex for 2 weeks in 10 sessions, and the other group received sham continuous theta burst stimulation over the same (P3) cortex for 2 weeks in 10 sessions. The measurements were done before and after rehabilitation. No follow-up was performed. Neglect patients with art constructive errors of painting were unaware of the group assignments; they were informed that they are going to undergo the treatment for their art constructive errors of painting and visuospatial unilateral
neglect. However, the cognitional therapist was aware of the neglect of patients’ group allocation. The inclusion criteria consisted of neglect due to stroke, art constructive errors of painting, having suffered a right-brain stroke, and being right-handed. The exclusion criteria was age less than 18 and more than 80 years, brain trauma, implanted heart pacemaker, a previous history of copying and coloring or painting deficit, epilepsy, cerebral edema, and intense pain. All 14 participants were right-handed; 10 (70%) men and 4 (30%) women aged between 46 and 79 years. In terms of the type of stroke, 6 (40%) participants had ischemic cerebral infarction and stroke onset date was before 6 months prior to the randomization in 6 (40%) of patients. There was no difference in demographic baseline characteristics in terms of age, sex, education, acute stage (stroke onset date was before 6 months), and chronic stage (stroke onset date was after 6 months), type of stroke, and outcomes in before the intervention (Table 1).

Assessment of art constructive errors of painting, and neglect and measurement technique

All participants were evaluated art constructive errors of painting, and neglect before and after treatment. Art constructive errors of painting measured using to detect of omission, size error, perseveration, deformation, and neglect in warm colors into the Figure Copying Test (Johannsen & Karnath, 2004), and Coloring Test (Blanke & Pasqualini, 2012). Unilateral neglect measured using the Line Bisection task (LBT) (Bonato, Priftis, Marenzi, & Zorzi, 2008; Guariglia, Matano, & Piccardi, 2014). They were also requested to attend for 2 weeks in 10 daily sessions of the prism adaption (PA) combined with continuous theta-burst transcranial magnetic stimulation (cTBS) in the experimental group and PA combined with sham cTBS in control group.

In the art constructive errors of the painting task, all participants completed the Figure copying Test and Coloring Test on an A4-sized plain paper before and after the rehabilitation. No time limit was considered for the test. Only the art constructive (visuospatial) errors were evaluated as coloring and copying of painting, and semantic art of painting errors or professional paint in the art errors were not assessed. Each error was scored as one.
Previous studies have shown the classification of art constructive errors of painting into
deformation, omission, and neglect of warm colors (using cold colors) in accordance with the
criteria determined by Olaf Blanke et al (Blanke & Pasqualini, 2012). We used new suggestions
for the detection of the classification of art constructive errors in the painting system. Constructive
painting errors were further classified into omission, deformation, small size error, neglect of warm
colors, and perseveration errors in the Figure copying Test and Coloring Test (Figure 2, 3). Deformation errors are the creation of a nonexistent form copying or coloring. Omission errors
mean that the painter ignores more than 50% of space in the square of coloring and deletes 1 part
of the landscape from the shape in Figure copying Test. Visuospatial size error means the painter
changes normal size painting to small size painting of Coloring and Figure copying Test. Neglect
of warm colors means that the painter changes colors of warm (yellow, light green and red) to
colors of cold, which is characterized by cold, hard, and metallic colors such as gray, black, dark
green, brown, and marine blue. Perseveration error is related to the repetition and addition to the
painting (Figure 2, 3). In the Coloring Test, the stroke patients were asked to coloring a multi-
object scene consisting of miniature style on an A4-sized plain paper. The coloring section ratio
was computed from the ratio of color omitted on the left side on A4 paper to the total score of
coloring canceled for neglect evaluation. We also calculated another score which was the ratio of
art constructive errors in the painting by the patient.

In the Figure copying Test, the stroke patients were asked to copy a multi-object scene consisting
of five figures on an A4 paper. Omission of at least one of the left-sided features of each figure
was scored as 1, the omission of each whole figure was scored as 2, and one preservation point
was given when left-sided figures were drawn on the right side. Each perseveration was scored as
1. The maximum score was 10 for neglect evaluation. We also calculated another score which was
the ratio of art constructive errors in the painting by the patient.

In the LBT, patients were instructed to bisect 40 horizontal lines including 10 lines on the right
side, 18 lines on the middle side, and 12 lines on the left side of the page. The absolute distance
between the patient’s bisection and the midpoint straight lines were computed.
TMS Intervention

We used a MagPro X100 machine (Magventure Company, Farum, Denmark) equipped with a commercially available figure-of-eight coil for cTBS. The experimental group received continuous theta-burst Stimulation (cTBS). The cTBS inhibitory protocol was 801 pulses in 3 bursts at 30 Hz and was repeated every 100 ms (5 Hz, θ rhythm) with 80% of RMT. The cTBS inhibitory protocol was applied in P3 on the intact parietal (P3), left side based on the EG 10/20 system in 10 sessions over a 2-week period (Yang et al., 2015). The control group underwent sham magnetic stimulation by tilting coil vertically (90°) same experimental true stimulation group (Rossi et al., 2007). The participant in both groups received intervention into days 10 per week for 2 weeks. Participants were blind to the type of therapy they received. These stroke patients tolerated cTBS treatment using 8-coil without the incidence of any complications. We has used a safety guideline for inhibitory protocol (Rossini et al., 2015).

Statistical analysis

Student’s T-test and Fisher exact test were used to compare the groups at baseline (PA combined with cTBS vs. PA alone) in continuous and dichotomous variables, respectively. Then, Repeated-Measures Analysis of Variance (ANOVA) was performed between the values of LBT, Figure copying Test, Coloring Test, and total art constructive errors of painting, with group (PA combined with cTBS vs. PA alone) as between-subject main factor and time (post-treatment vs. pre-treatment) as within-subject main factor. In each ANOVA model, cTBS was assumed effective if group × time interaction was found significant indicating more score changes in the experimental group compared to the control group. For all statistical analyses, a P value <0.05 was considered to be significant.
Results

Change in the art constructive errors of painting

In our present study, the primary outcome was changed in the art constructive errors of painting Table2. All patients in both groups showed improvement in art constructive errors of painting effect (total error score of both the Figure copying Test and Coloring Test), as revealed by Repeated-measures analysis of variance (ANOVA). In a repeated ANOVA model of art constructive errors of painting scores, the time factor was significant (F=130.567, P=0.001) indicating that both groups’ art constructive errors of painting scores (total error score) improved after the treatment. However, the group × time was not significant (F=1.612, P=0.228) indicating no difference between CTBS+PA and PA alone on art constructive errors of painting scores changes.

Figure 1 shows art constructive errors of painting scores’ means in both groups before and after 10 sessions of rehabilitation without painting practice.

All patients showed, on average, 5.3 (mean ± SD, 5.35 ±1.15) errors on art constructive errors of painting before rehabilitation compared to only 1.5 (mean ± SD, 1.50 ±1.62) errors on art constructive errors of painting after the intervention. Visuospatial omission, deformation errors, and neglect of warm colors (using cold colors) were the most frequent errors in the Figure copying Test, and Coloring Test followed by stroke patient with neglect in the pattern of painting’ errors. A reduction was observed in the scores of all classification of art constructive errors of painting which suggests improvement in errors of painting symptoms in participants of both groups after intervention (Figure1).

Classification of art constructive errors of painting, omission, deformation, perseveration (addition), neglect of warm color (using cold color), and size errors were detected to sum of the score of errors in the participant before and after intervention (Examples are shown in Figure1, 2).

The results of increase significant improvement in the art constructive errors of painting and neglect are summarized in Figure1.

Change in the neglect scores
Neglect scores descriptive statistics before and after the rehabilitation are provided in Table 2. In a repeated ANOVA model with the LBT, Figure copying Test, and Coloring Test scores as the outcome variable, the time factor was significant (in the LBT, F=31.630, p<0.001), (in Figure copying Test, F= 64.438, P=0.001), and (in the Coloring test, F=117.923, p<0.001) indicating that both groups’ neglect variable scores improved after the rehabilitation. However, the group × time was not significant in the LBT (F=0.338, p=0.572), in the Figure copying Test (F=2.959, P=0.111), and the Coloring Test (F=4.493, P=0.056) indicating no difference between the PA combined with cTBS group in the LBT, Figure copying Test, and Coloring Test scores changes compared to the PA alone group (Figure 1).

Discussion
The pilot study showed that in all stroke patients with neglect and art constructive errors of painting were improved after 10 sessions of rehabilitation with PA alone and cTBS combined with PA. Art constructive errors of painting were classified into visuospatial omission error, deformation error, perseveration error, visuospatial small size errors, and neglect of warm colors (using cold colors) in stroke patients with neglect. The most frequent errors were a visuospatial omission, deformation, and neglect of warm colors.

Prism adaption has been used for neglect treatment with variable success. However, our findings corroborate some previous trials reporting neglect approaches for rehabilitation (De Wit, Ten Brink, Visser-Meily, & Nijboer, 2018; Vaes et al., 2018). Improved visuospatial unilateral neglect symptoms as a result of rehabilitation may translate to improvements in the art constructive errors of painting. Some other clinical trials did not find such an effect for the prism (Barrett, Goedert, & Basso, 2012; Ten Brink et al., 2017; Turton, O'Leary, Gabb, Woodward, & Gilchirst, 2010). Differences in the clinical trials’ design (prism glasses with 6 degrees of the visual field displacement compared to prism glasses with 10 degrees in current study), the employed evaluation (measured using “Aiming” compared to measured using “Where”), and the characteristics of the recruited stroke patients with visuospatial unilateral neglect can explain this disparity. Another explanation is the fact that in all neglect patients received modification of prism adaption by mirror therapy at baseline. In contrast to prism adaption, mirror therapy showed improvement in visuospatial unilateral neglect with success (Pulyk & Hyryavets, 2018). It was
previously shown that mirror therapy 3 times a week for 20 minutes for 3 months performed better at neglect test after the intervention compared to the control group. Mirror training acts by activating mirror neurons system (Pulyk & Hyryavets, 2018; Zhang, Fong, Welage, & Liu, 2018).

Trials on cTBS rehabilitation approaches over the left intact parietal cortex have showed it as an effective therapy in the neglect (Cazzoli et al., 2012; Cotoi et al., 2019). We found that combination of PA was effective in the art of constructive errors in painting, and neglect recovery and was not even more efficacious when cTBS was added. One possible explanation is the near-complete rehabilitation effect of the art constructive errors in painting and neglect tests in both groups. All patients showed, on average, 5.3 errors in painting before rehabilitation compared to only 1.5 error in painting after rehabilitation.

In the present study, it was hypothesized that the recovery combination stimulated and employed more networks of the brain, which might improve art constructive errors of painting and unilateral neglect in stroke patients. More studies are needed with functional and structural neuroimaging to verify this hypothesis. In fact, previous studies have shown the promotion and correlation between changes in functional connectivity and structural in attention network measured using neuroimaging in PA and cTBS (Fu et al., 2017; Nyffeler et al., 2019; Tsujimoto et al., 2019), and reduction in pathological hyperexcitability (Corbetta & Shulman, 2011; G Koch et al., 2012; Giacomo Koch et al., 2008), and the new mechanism of combined rehabilitation may explain the implicit recovery effect seen in stroke-induced neglect, and the art constructive errors of painting in the current study.

In contrast to implicit recovery (without practice) in the art constructive errors of painting, previous studies have been based on writing, imaging, painting, and relearning of practices (Pachalska, Grochmal-Bach, Wilk, & Buliński, 2008). However, there is limited research into therapy for adults with acquired art constructive errors in painting. Previous studies on the art constructive errors of painting were focused on after stroke effects in professional painters (Pachalska et al., 2008; Rhee et al., 2016). Although patients in our study were not professional painters, they presented errors in the painting like professional painters after stroke.

Findings regarding the classification of constructive errors in painting showed that omission errors were most common in patients with stroke-induced neglect. Omission error outcome was consistent with studies on professional artists (Bätzner & Hennerici, 2006; H. Bätzner & M.
Hennerici, 2007; Blanke & Pasqualini, 2012; Rhee et al., 2016). Right-hemisphere stroke patients showed mostly left space omission errors and changes in painting style (J.-M. Annoni et al., 2005; H. Bätzner & M. Hennerici, 2007; H. Bätzner & M. G. Hennerici, 2007; Mazzucchi et al., 2013; Rhee et al., 2016). In contrast, left-hemisphere stroke patients showed painting without omission (Mazzucchi et al., 2013).

In our study, a wider use of cold colors (brown and marine blue) and minimal use of color on the left side was observed. Some neglect patients used minimal color on the left whereas they colored the right side completely and evenly. Likewise, the selection of cold colors was observed before the intervention in professional artists with stroke-induced neglect (Bätzner & Hennerici, 2006; H. Bätzner & M. G. Hennerici, 2007; Blanke & Pasqualini, 2012; Mazzucchi et al., 2013; Rhee et al., 2016). After rehabilitation, a wider use of warm (yellow, light green, and red) and cold colors were observed in stroke patients with neglect.

In the current study, patients with neglect used minimal size in drawing. However, our findings corroborate some previous studies reporting professional artists with neglect symptoms for a bi-dimensional perspective, in an attempt to avoid depth representation on their part of the painting (Bätzner & Hennerici, 2006; Mazzucchi et al., 2013). Unreality painting outcome of small size, deformation, and neglect was consistent with studies in professional artists with right-hemisphere stroke (J.-M. Annoni et al., 2005; H. Bätzner & M. Hennerici, 2007; H. Bätzner & M. G. Hennerici, 2007; Blanke & Pasqualini, 2012; Mazzucchi et al., 2013; Rhee et al., 2016; Rode et al., 2017). In contrast, Left-hemisphere stroke patients often remained hemiplegic (right-sided) and learned to hold the brush with their left hand with practice. The beginner style painting persisted in patients (Mazzucchi et al., 2013). Disrupting of estimate in-depth and distance related neglect mechanisms may underlie the small size perception, omission and deforming effect seen in art constructive errors of painting in stroke patients (H. Bätzner & M. G. Hennerici, 2007; Rode et al., 2017). The brain processing after rehabilitation in visuospatial unilateral neglect may translate to improvements in the art of constructive errors in painting.

In the present study, patients with frontal damage had perseveration. Likewise, Frontal-brain stroke in professional painters showed mostly perseveration (adding) errors (Bätzner & Hennerici, 2006; H. Bätzner & M. Hennerici, 2007; H. Bätzner & M. G. Hennerici, 2007; Blanke & Pasqualini, 2012; Mazzucchi et al., 2013).
This pilot study had some limitations, including the only a single-center was assessed, thus the study had a relatively limited sample size. Also, 40% of our stroke patients were in the acute phase with recovery. Likewise, continuous Theta-Burst Transcranial Magnetic Stimulation was reported as useful in rehabilitation in terms of neglect in the acute phases in some clinical trials (Kim, Chun, Kim, & Lee, 2013; Nyffeler et al., 2019). Nevertheless, there was no statistically significant difference between the 2 groups at baseline in the time since the onset of the acute phase (Table 1). The absence of cTBS alone for comparison was also a limitation in the present study; however, cTBS has been conducted in a previous study in neglect recovery (Cazzoli et al., 2012). More research is required to replicate our findings in a larger group.

The present study was the first clinical trial of a combination of PA and cTBS therapies for the art of constructive errors of painting without practice in painting, and neglect symptoms. Further studies are suggested on the relationship between the art constructive errors of painting and underlying impaired perception mechanisms of the brain using electrophysiological and, functional imaging to verify whether brain regions are activated or deactivated.

**Conclusions**

An influence was found between art constructive errors of painting system and neglect in stroke patients. Art constructive errors of painting patterns were determined to improve size discrepancy, omission, deformation, perseveration, and neglect of warm colors. The current results showed that art constructive errors of painting and neglect may be affected by rehabilitation and art educational strategies. Neglect appears to specifically affect the painting systems of stroke patients. The novel PA combined with cTBS and PA alone method could be potentially useful tools for rehabilitating patients with stroke-induced art constructive errors of painting, and neglect.

**Authors’ Contribution:** Study concept and design: Shole Vatanparasti. Analysis and interpretation of data: Anoshirvan Kazemnejad and Shole Vatanparasti. Drafting of the manuscript: Shole Vatanparasti. Critical revision of the manuscript for important intellectual content: Shole Vatanparasti. Study supervision: Shahram Oveisgharan. Statistical analysis: Anoshirvan Kazemnejad and Shole Vatanparasti.

**Ethical considerations and consent forms:** The study was approved by the Ethics Committee of Iran University of Medical Sciences. All the subjects gave their informed consents before
conducting the study [IR.IUMS.REC.1396.93012334]. This study was registered at https://fa.irct.ir/login Iranian Registry of Clinical Trials [IRCT20170423033606N3].

**Declaration of Interest:** None

**Conflict of interest:** None

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Table 1. Patient’s characteristics†

| N/Intervention | Age (yr.) | Sex (M/F) | Grade-school education | Region of the stroke: P, T, F, O, IC, TH | Time since stroke onset | Type of the stroke | Art constructive errors of painting |
|----------------|-----------|-----------|------------------------|------------------------------------------|------------------------|-------------------|-----------------------------------|
| 1) PA          | 67        | M         | 16                     | RT, RF, RP, TH                           | Chronic               | Hemorrhage        | Size, deformation, neglect of warm colors, omission |
| 2) PA          | 68        | M         | 9                      | RF, RT                                  | Chronic               | Hemorrhage        | Size, deformation, neglect of warm colors, omission, perseveration |
| 3) PA          | 63        | M         | 9                      | RO, RP                                  | Acute                 | Ischemic          | Size, deformation, neglect of warm colors, omission |
| 4) PA          | 70        | M         | 16                     | RT, RF                                  | Chronic               | Ischemic          | Size, deformation, omission         |
| 5) PA          | 65        | M         | 12                     | RT                                      | Chronic               | Ischemic          | Size, deformation, omission         |
| 6) PA          | 46        | F         | 16                     | RTH                                     | Acute                 | Hemorrhage        | Size                              |
| 7) PA          | 79        | F         | 0                      | RP                                      | Acute                 | Ischemic          | Size, deformation, neglect of warm colors, omission |
| 1) CTBS+ PA    | 53        | M         | 11                     | RP                                      | Chronic               | Ischemic          | Size, deformation, neglect of warm colors, omission |
| 2) CTBS+ PA    | 77        | M         | 0                      | RT, RP, RO                              | Chronic               | Ischemic          | Size, deformation, omission         |
| 3) CTBS+ PA    | 77        | M         | 5                      | IN                                      | Acute                 | Ischemic          | Size, deformation, neglect of warm colors, omission |
| 4) CTBS+ PA    | 70        | M         | 16                     | RF, RP, RT                              | Chronic               | Hemorrhage        | Size, deformation, omission, perseveration |
| 5) CTBS+ PA    | 67        | F         | 0                      | RT, RTH                                | Acute                 | Hemorrhage        | Size, deformation, neglect of warm colors, omission |
| 6) CTBS+ PA    | 62        | M         | 12                     | RF, RT, RP                             | Acute                 | Hemorrhage        | Size, deformation, omission, perseveration |
| 7) CTBS+ PA    | 67        | F         | 12                     | RT, RP, RF                             | Chronic               | Ischemic          | Size, deformation, neglect of warm colors, omission, perseveration |

PA mean (SD) cTBS+ PA mean (SD) P value†

|                  | Mean (SD) | P value |                  | Mean (SD) | P value |                  |                  |                  |
|------------------|-----------|---------|------------------|-----------|---------|------------------|------------------|------------------|
|                  |           |         |                  |           |         |                  |                  |                  |
|                  | 65.42 (9.98) | 0.72 | 11.00 (5.84) | 8.00 (6.35) | 0.35 | F               | P                | TH               |
|                  | 67.57 (8.44) |         |                  | 5.28 (1.60) |         | p=0.70           | p=0.70           | 5.24 (0.53) | p=0.83 |

†Dichotomous variables are compared with Fisher exact test and quantitative variables with t-test.

Abbreviations: P, Cortex parietal; T, Cortex temporal; F, Cortex Frontal; R, right; IN, internal capsule; TH, thalamus; O, occipital; CTBS, continuous theta-burst transcranial magnetic stimulation; PA, prism adaptation; Chronic, Time since stroke onset > 6 months; Acute, Time since stroke onset < 6 months.
Table 2. Art constructive errors of painting, and visuospatal neglect measurement before and after the rehabilitation.

| Outcome                                      | Before intervention; mean ± (SD) | After intervention; mean ± (SD) | Repeated ANOVA |
|----------------------------------------------|----------------------------------|---------------------------------|----------------|
|                                              | PA+ cTBS                         | PA                              |                |
| Line Bisection Test                          | 33.70±(15.65)                    | 27.62±(11.69)                   | **p<0.001**    |
| Coloring Test                                | 65.42±(10.27)                    | 43.71±(24.47)                   | **p<0.001**    |
| Figure copying Test                          | 6.14±(1.21)                      | 3.71±(2.75)                     | **p<0.001**    |
| Art constructive errors of painting          | 5.42±(0.53)                      | 5.28±(1.40)                     | **p<0.001**    |

NOTE. Values are mean ± (SD). * Significant difference between pre-intervention and post-intervention of the group at P<0.05 by repeated ANOVA model, time factor. **Significant difference between groups at P<0.05 by repeated ANOVA model, the group × time factor. NOTE. Values are mean ± (SD). * Significant difference between pre-intervention and post-intervention of the group at P<0.05 by repeated ANOVA model, time factor. **Significant difference between groups at P<0.05 by repeated ANOVA model, the group × time factor.

Abbreviations: cTBS, continuous Theta-Burst Transcranial Magnetic Stimulation; PA, prism adaptation.
Figure 1. Art constructive errors of painting, and visuospatial neglect measurement before and after the rehabilitation. Figure on the left side shows patients with the classification of art constructive errors of painting in the Figure copying Test and Coloring Test of rehabilitation without painting practice before and after 10 sessions. Figure on the right side shows stroke patients’ scores in the neglect and art constructive errors of painting (total errors) of rehabilitation before and after 10 sessions. All patients show to rehabilitation significantly in art constructive errors (measured using pattern of painting’ errors in FCT, and CT), and neglect symptoms (measured by LBT, FCT, and CT). Asterisks indicate results that were significant using repeated ANOVA model, time factor: *P<0.05, repeated ANOVA model, the group × time factor: **P<0.05

Abbreviations: msc.b, minimal size color on the left side errors before rehabilitation; msc.a, minimal size color on the left side errors after rehabilitation; cc.b, cold colors used (neglect of warm colors) before rehabilitation; cc.a, cold colors used (neglect of warm colors) after rehabilitation; oc.b, omission color erreore before rehabilitation; oc.a, omission color erreore after rehabilitation; pc.b, perseveration color errors before rehabilitation; pc.a, perseveration color errors after rehabilitation; sc.b, small size copying errors before rehabilitation; sc.a, small size copying errors after rehabilitation; dc.b, deformation copying errors before rehabilitation; dc.a, deformation copying errors after rehabilitation; oco.b, omission copying erreore before rehabilitation; oco.a, omission copying erreore after rehabilitation; pco.b, perseveration copying errors before rehabilitation; pco.a, perseveration copying errors after rehabilitation; P.total errors b, total errors score of art constructive errors of painting before rehabilitation; P.total errors a, total errors score of art constructive errors of painting after rehabilitation; cTBS, continuous theta-burst transcranial magnetic stimulation; PA, Prism adaptation; FCT, FigureCopying Test; CT, Coloring Test; LBT, Line Bisection Test.
| PA+CTBS group before intervention | PA+CTBS group after intervention | PA group before intervention | PA group after intervention |
|----------------------------------|---------------------------------|-----------------------------|-----------------------------|
| ![Image](image1)                 | ![Image](image2)                | ![Image](image3)            | ![Image](image4)            |
| ![Image](image5)                 | ![Image](image6)                | ![Image](image7)            | ![Image](image8)            |
| ![Image](image9)                 | ![Image](image10)               | ![Image](image11)           | ![Image](image12)           |
| ![Image](image13)                | ![Image](image14)               | ![Image](image15)           | ![Image](image16)           |
| ![Image](image17)                | ![Image](image18)               | ![Image](image19)           | ![Image](image20)           |
| ![Image](image21)                | ![Image](image22)               | ![Image](image23)           | ![Image](image24)           |
| ![Image](image25)                | ![Image](image26)               | ![Image](image27)           | ![Image](image28)           |
| ![Image](image29)                | ![Image](image30)               | ![Image](image31)           | ![Image](image32)           |
| ![Image](image33)                | ![Image](image34)               | ![Image](image35)           | ![Image](image36)           |
Figure 2. The classification of art constructive errors in the painting of coloring in patients with neglect used in this study. The figure on the left side of columns shows the response of the patients with art constructive errors of painting in Coloring Test and neglect before the intervention. The patients change often warm colors (yellow, light green and red) to cold colors, that are characterized by cold, hard, and metallic colors such as gray, black, dark green, brown, and marine blue (neglect in warm colors), and minimal color on the left side. Those on the right side of columns are examples of the response of the patients with art constructive errors of painting in Coloring Test and neglect of rehabilitation after 10 sessions. The patients use both warm colors and cold colors in total paper.
| PA+CTBS group before intervention | PA+CTBS group after intervention | PA group before intervention | PA group after intervention |
|---------------------------------|---------------------------------|-----------------------------|-----------------------------|
| ![Image](image1.png)            | ![Image](image2.png)           |                             |                             |
| ![Image](image3.png)            | ![Image](image4.png)           |                             |                             |
| ![Image](image5.png)            | ![Image](image6.png)           | ![Image](image7.png)       | ![Image](image8.png)       |
| Deformation error               |                                 |                             |                             |
| ![Image](image9.png)            | ![Image](image10.png)          |                             |                             |
| ![Image](image11.png)           | ![Image](image12.png)          |                             |                             |
| Perseveration error             |                                 |                             |                             |
| ![Image](image13.png)           | ![Image](image14.png)          |                             |                             |
| ![Image](image15.png)           | ![Image](image16.png)          |                             |                             |
| Size error                      |                                 |                             |                             |
| ![Image](image17.png)           | ![Image](image18.png)          |                             |                             |
|                                 | ![Image](image19.png)          |                             |                             |
Figure 3. The classification of art constructive errors in painting of figure copying in stroke patients with neglect used in this study. The figure on the left side of columns shows the response of the patients with art constructive errors of painting in Figure copying Test and neglect before intervention. Those on the right side of columns are examples of the response of the patients with art constructive errors of painting in Figure copying Test and neglect of rehabilitation after 10 sessions.