CASE STUDY

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GOAL-ORIENTED NEUROPSYCHOLOGICAL REHABILITATION WITH EEG-NEUROFEEDBACK FOR A VISUAL ARTIST WITH PTSD RESULTING FROM SARS-COV-2 INFECTION, FOLLOWED BY A SEVERE COURSE OF NEUROCOVID AND THE SEQUELAE OF LONG TERM PHARMACOLOGICALLY-INDUCED COMA

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SUMMARY

Background: The purpose of the study was twofold: 1) to evaluate the effectiveness of goal-oriented neuropsychological rehabilitation, with EEG-Neurofeedback, developed for a visual artist with PTSD resulting from infection with SARS-CoV-2, followed by a severe course of neuroCovid and sequelae of long term pharmacological coma, 2) to evaluate QEEG/ERP results showing a reduction of late-onset PTSD symptoms (as defined by DSM-5) over the course of the subject's rehabilitation.

Case study: The present study describes a 67-year-old right-handed visual artist with PTSD after infection with SARS-CoV-2, resulting in severe course of COVID-19 complicated by acute respiratory distress syndrome (ARDS). She was referred to the ICU, put on a respirator and treated during 13 weeks of pharmacologically induced coma. After returning home she received rehabilitation to improve motor functioning, and was referred for further diagnosis and therapy to the Reintegration and Training Center of the Polish Neuropsychological Society. In neuropsychological diagnosis she presented with neurocognitive dysfunctions, including lost ability to paint. In the course of rehabilitation she received a program of rehabilitation with two components:
1. **Program A,** consisting in goal-oriented neuropsychological rehabilitation, including art therapy, aimed at the reduction of the neurocognitive dysfunctions (Pąchalska 2008). This program lasted for 9 months (from the beginning of March till the end of November 2022).
2. **Program B,** based on the most commonly used form of EEG-Neurofeedback: frequency/ power EEG-Neurofeedback, using 2 bipolar surface electrodes, called "surface neurofeedback" (Kropotov 2016). She received Theta/ Beta, SMR training, including (1) at C3, strengthening Beta1 and inhibiting Theta + inhibiting Beta 2,and (2) at C4, strengthening SMR and inhibiting Theta + inhibiting Beta, based on the international 10-20 system (Thompson & Thompson 2012). This program was given after a diagnosis of PTSD with late onset (as defined by DSM-5), from the beginning of August till the end of November, twice a week.

Conclusions: Almost all the short and the long-term side effects of neuroCOVID (including the PTSD) were reduced in severity. The artist showed marked improvement and was able to return to painting. The artwork she made after her illness is in high demand with art collectors, which has improved the patient's quality of life.
Goal-oriented neuropsychological rehabilitation, with art therapy, supported with EEG-Neurofeedback administered for a visual artist with PTSD with delayed onset (as defined by DSM-5) resulting from infection with SARS-CoV-2, followed by severe neuroCovid symptoms and the sequelae of long-term pharmacologically-induced coma, canbe helpful in the reduction of short term side effects, such as neurocognitive dysfunctions (attention, memory, dysexecutive symptoms) and long-term side effects, such as various physical and mental symptoms, including PTSD. It can be also helpful in the reintegration of the Self System.

Key words: neuroCOVID-19, neurocognitive dysfunctions, PTSD, goal-oriented cognitive training, art therapy, ERPs, EEG-Neurofeedback

INTRODUCTION

Since the first confirmed case of COVID 19 was reported in Wuhan, China, on Decembe r 31, 2019, the novel coronavirus (SARS-CoV-2) responsible for this disease has caused a pandemic. Global statistics, as of early December 2022, show that:

- 662.6 million people have been infected;
- 20.7 million people are still ill;
- 6.7 million people have died;
- 635.2 million people have survived[1].

Many of the survivors, however, are still struggling with various sequelae of-COVID-19 (Aknin et al., 2021; Pachalska et al., 2021). SinceSARS-CoV-2 was first detected in humans, studies have shown that COVID-19 can produce a wide array of symptoms, ranging from mild – such as anosmia, ageusia, latent blinking and latent squint (Belvisetal., 2020), headaches, dizziness,and confusion (Lecheinetal.,2020) - to more serious sequelae, including cognitive impairment, seizures, delirium, psychosis, and stroke. Longer-term neurological challenges or damage may also occur (Bougakov et al., 2020; Solomon, 2021; Rogersetal., 2020; Mao et al., 2020; Zanin et al., 2020; Aknin et al., 2021). Observing the numerous mutations of SARS-Cov-2, we cannot say that the list of pathognomonic symptoms is closed. The pandemic has negatively affected every aspect of people's lives, including economic and social functioning, as well as impairments of physical and mental health(Aknin,2021).It turns out that both short-term and long-term neurological or mental disorders can occur in the aftermath of thedisease,which is a challenge for modern medicine.

Knowledge about the effects of COVID-19 on the brain has accumulated rapidly, as reflected in the increasing use of the term "neuroCOVID" (Goldberg et al., 2020: Pąchalska et al., 2021; MacQueen & MacQueen, 2021). The progression of brain damage associated with neuroCOVID is complex and not yet fully understood. However, we know that there is neurondamage, as well as break down or modification of the neuronal connections that underlie normal cognitive, emotional and behavioral processes. This is what produces the persistence of the neurological and neuropsychological symptoms of neuroCOVID, long after the virus itself has disappeared from the organism.

One of the most serious consequences of neuroCOVID-19 is the development of post-traumatic stress disorder (PTSD) Meliet al.,2019; Righty et al., 2019; Remuzzi & Remuzzi, 2020; Qi et al., 2020; Wesemann et al.,2020). There are a number of possible and diverse causes of PTSD in COVID-19 survivors.The most important of these are:

1. hospitalization for COVID-19, which in and of itself is a potentially traumatic experience, especially when the patient is isolated from family and friends and surrounding by medical pers onnel wearing protective devices;
2. the unprecedented ubiquity of public information about the SARS-CoV-2 pan-

[1] https://www.worldometers.info/coronavirus/

demic andCOVID-19 cases,with a steadily increasing intensity of reporting by traditional media, especially television, providing daily updates in the increasing numbers of hospitalizations and deaths, and the associated perception that exposure to this virus is a threat to survival, even for those with moderate infection.

It should come as no surprise, then, to find a high rate of PTSD symptoms in COVID-19 survivors (Abdalla et al.2021). PTSD is a severe but treatable mental disorder that develops after exposure to a life-threatening traumatic event. The clinical symptoms of PTSD, as it is summarized by Tarsitani et al. (2021) include:

- recurrent intrusive memories;
- flashbacks regarding the trauma;
- sleep disorders and nightmares:
- avoidance o ftopics related to the trauma;
- avariety of mood disorders and dissociative symptoms;
- cognitive symptoms.

In the long term, PTSD is associated with mood disorders, abuse of alcohol and other psychoactive substances, suicide and attempted suicide, and physical health conditions, such as hypertension, obesity and coronary heart disease (McFarlane, 2010).

The purpose of the study was twofold: 1) to evaluate the effectiveness of goal-oriented neuropsychological rehabilitation, with EEG-Neurofeedback, developed for a visual artist with PTSD resulting from infection with SARS-CoV-2, followed by a severe course of neuroCovid and sequelae of long term pharmacological coma, 2) to evaluate QEEG/ERP results showing a reduction of late-onset PTSD symptoms (as defined by DSM-5) over the course of the subject's rehabilitation.

CASE STUDY

The present study describes a 67-year-old right-handed visual artist with PTSD resulting from SARS-CoV-2 infection, followed by a severe course of neuroCovid complicated by acute respiratory distress syndrome (ARDS) and the sequelae of long term pharmacologically-induced coma.

She became ill on November 22, 2021. The first symptom was severe headaches, lasting about four days, which she handled with over-the-counter medicines. Other symptoms pathognomonic for COVID-19 soon joined in: general weakness, a dry cough and a fever of up to 39°C. After two weeks, in early December of 2021, respiratory dyspnea increased, and the patient was admitted to the Infectious Disease Unit. An Abbot PCR control antigen test was positive for COVID-19. Hypertension and pneumonia of COVID-19 etiology were diagnosed by imaging studies. Two days later, her persistent cough and expectoration of pink secretions (tinged with blood) intensified, as well as shortness of breath, and the patient required oxygen therapy. Dexamethasone was introduced to reduce inflammation.

After another two days, the patient's general condition deteriorated. A CT scan of the lungs showed extensive, irregular interstitial darkening involving prominent lung fields. This image is consistent with COVID-19 lesions. The diaphragm displayed normal topography and smooth outlines. The diaphragmatic and rib angles were free. The silhouette of the heart was normal. The pulmonary hilum was not dilated. AngioTK examination of the pulmonary arteries showed fine, diffuse embolic material within the arteries to the basal segments (sX) of both lungs. Other than that, the visible vessels were normally contrasted. There were extensive areas of milky glass in both lungs, which is typical in COVID-19, as well as trace amounts of free fluid in the pleural cavities. A CT scan of the head with contrast showed a homogeneous brain without focal changes. The ventricular system was normal: symmetrical and not dilated. The basal reservoir showed apreserved lumen. No traumatic changes were found in the visualized skeletal system. Acute respiratory distress syndrome (ARDS) was diagnosed and she was transferred to the ICU, intubated, and ventilated on VC SIMV, fio2 100% PEEP 14. Circulation was supported with Levonor infusion. Forced diuresis was successful. The next day, the patient's condition deteriorated further. Antibiotic therapy was continued and Tocilizumab (TCZ)was introduced, a monoclonal antibody against interleukin-6 (IL-6), which has emerged as an alternative treatment for COVID-19 patients with a risk of cytokine storms (see also Luo et al. 2020). Prone positioning was applied. Ventilator settings were verified after PEEP12, O265 gasometers. She was ventilated during the day in VC SIMV mode. After being turned onto her back, there was a decrease in 0_2 saturation, down to fio2 0.8 PEEP 14 cm H_20. In the evening, the patient was again turned on her stomach (prone arm position), which resulted in improved ventilation and a decrease in fio2 to 0.65. Her circulation was inefficient, but stabilized with Levonor infusion. She was fed parenterally and with small amounts of gastric infusion. She was not feverish. On the following day, the patient's condition continued to be very serious. She was ventilated during the day in VC SIMV mode, while at night she was reversed into prone arm position. An improvement in ventilation parameters was achieved: fio2 0.5 PEEP 12 cm H_20. In the afternoon of the next day, the patient's condition was still very serious. She was still sedated, with ventilatory sparing, and the ventilation mode was changed to BIPAP. The parameters were corrected after gasometry using a COBAS apparatus, with fio2 at 0.75 sat. 91. An obstructed arterial line on the left radial artery was changed to a new one. Parenteral feeding was extended due to the need to turn her on her stomach. In the following days, since the patient's condition continued to be very severe, monitoring of baseline and additional documentation was carried out according to the templates specified in the special appendices documenting all treatments in accordance with world standards in this regard (see also: Giustivi et al. 2021; Sottile et al. 2022).

After 10 weeks in the ICU, the patient was awakened from the pharmacological coma and disconnected from the ventilator. However, she presented with visual hallucinations (she reported seeing dying people, Hell, and creatures wandering there), as well as a lack of mental acuity and disorientation in time and space,

leading to a diagnosis of "brain fog." After two hours, the patient's condition deteriorated again. She was reconnected to the ventilator and continued to be ventilated in SIMV mode, fio2 100% PEEP 14. In the evening, the patient was again turned onto her stomach, which resulted in improved ventilation and a reduction in fio2 to 0.65. In the prone arm position she spent an average of approximately 6.2 hours (IQR, 4.8-6.7 hours) per day. Her circulation was still inefficient, so she continued to be stabilized with Levonor infusion. Again, when turned onto her back, there was a decrease in 0_2 saturation to fio 2 0.8 PEEP 14 cm H_20. The prognosis was unfavorable. The family was informed that the patient would probably not survive.

One week later, at the request of her family, the patient was provided with additional limited rehabilitation in an isolated room by therapists wearing full personal protective equipment (see also: Tamamura et al., 2022). This included passive movement and lung stimulation with polarized light (Bioptron quantum hyperlight) three times a day for 8 minutes, continued for 3 weeks. The patient's condition began to gradually improve. After 13 weeks, she was again awakened from the pharmacological coma, began to breathe independently for 8 or more hours, and regained consciousness. However, she was generally weak, sporadically confused, and her mood was very depressive.The prognosis was still uncertain.

In an extraordinary step, her family, considering the overall situation, decided to take her home. At discharge from the ICU, she received a diagnosis of COVID-19, U-07.1 according to ICD-10 (with confirmed presence of SARS COV-2), complicated by acute respiratory distress syndrome (ARDS). At discharge from the ICU, she received a diagnosis of COVID-19, U-07.1 according to ICD-10 (with confirmed presence of SARS COV-2), complicated by acute respiratory distress syndrome (ARDS). The patient's daughters (one is a nurse, the other a physiotherapist) were trained how to use a portable ventilator, to which she needed to be connected overnight. A humidifier was used to help stabilize the relative humidity in her home. Home rehabilitation was introduced, with the patient exercizing in upright sitting position, along with functional independence exercises, such as grooming**,** getting out of bed, cognitive comprehension, including use of smartphones and social media. 10 days later, while standing upright, the patient again lost consciousness; atrial fibrillation and tachycardia were detected, and she was admitted to a cardiovascular intensive care unit (CICU); after four days she was sent to the cardiology department, where she was hospitalized for 2 weeks. Clostridioides difficile (C. difficile) was found. She had diarrhea, andantibiotic therapy was introduced, as well as other treatment. Finally, she lost 21 kilograms, and was very week. At discharge, the patient was able to breath independently, groom herself, eat with minimal assistance, and sit upright for a few minutes on a high wheelchair that stabilized her back and head.

Home rehabilitation

After her second return home, she immediately received home rehabilitation (full-body massage, physiotherapy exercises passive and active movement, as

Fig. 1. The artist's copy of a painting of St. Joseph by Boleslaw Barbacki (ca. 1930), located in the Basilica of St. Margaret in Nowy Sacz, Poland. This work was done by the artist before her illness, based on a postcard of the original.
Source: the Rev. Piotr Gora, with permission

well as functional independence exercises; see Gillick 2011; Pąchalska 2008) to prevent the loss of ability to perform activities of daily living. After two weeks of home rehabilitation, the patient was already able to sit for 30 minutes in a high wheelchair that stabilized her back and head. However, as her physical conditions improved, her mental condition deteriorated. The patient claimed that she could not paint or copy her favorite paintings, which she made for churches (see Fig. 1), and icons, which she had offered for sale. She also complained that the financial situation resulting from the loss of gainful employment was highly stressful.

Neuropsychological testing

In early March of 2022, four months after contracting Covid-19, the patientwas referred for further diagnosis and therapy at the Reintegration and Training Center of the Polish Neuropsychological Society. The neuropsychological testing administered here is presented in Table 1. Multiple deficits were found in the first examination. The neurocognitive disorders worsened slightly in stressful situations, or when fatigue developed, and were not under her conscious control.

Goal oriented neuropsychological rehabilitation

The patient then began the long road to rehabilitation in earnest. She received a program of goal-oriented neuropsychological rehabilitation, which was designed to reduce her neurocognitive dysfunctions (Pąchalska 2008). This included mainly cognitive training, which was given for 9 months (from the beginning

Table 1. Neuropsychological testing in examination 1, and 2

Measure	Exam. 1	Exam. 2
WAIS-R		
IQ – Full	61.5/100	104.5/100
IQ – Verbal	63.5/100	107.5/100
IQ – Nonverbal	58.5/100	101.5/100
Wechsler Memory Scale WMS-III, PL (Pąchalska & Lipowska 2006)		
WMS-III: Attention Spatial Span	3 (1st %ile)	12 (75th %ile)
WAIS-III: Visuospatial Ability Block Design	4 (1st %ile)	8 (25th %ile)
WMS-III Immediate logical memory	10/24	18/24
WMS-III Delayed logical memory	7/24	19/24
WMS-III Immediate visual recall	8/41	36/41
WMS-III Delayed visual recall	5/41	25/41
WMS-III Verbal memory Short Delay Free Recall	0/9(<1st %ile)	2/9 (<1st %ile)
WMS-III Verbal memory Long Free Recall	0/9(<1st %ile)	2/9 (<1st %ile)
WMS-III Verbal memory Long Delay Cue Recall	0/9(<1st %ile)	2/9 (<1st %ile)
Trial Making Test, TMT		
TMT Executive Functions– Number Sequencing	151 sec (<1st %ile)	55 sec (10th %ile)
TMT Executive Functions – Number Letter Sequencing	Discontinued	150 sec (<1st %ile)
The Stroop Colour and Word Test (SCWT)		
Color	91 sec (<1st %ile)	41 sec (16th %ile)
Word	42 sec (63rd %ile)	28 sec (25th %ile)
Interferences	Discontinued	128 sec (<1th %ile)
Wisconsin Card Sorting Test (**WCST**)		
Categories	0 (2-5th %ile)	2 (>16th %ile)
Perseverative Errors	46 (<1th %ile)	19 (37th percentile)
Conceptual Level Responses	63 (<19th %ile)	48 (45th%ile)
Fail to Maintain Sets	Discontinued	4 (2-5th %ile)
Authorized Polish Version of the Boston Naming Test (Pąchalska & MacQueen 1998)		
Naming – total number of errors	27/60	1/60
Polish Version of the Token Test (Pachalska 1996)		
Understanding – total number of errors	11/50	1/50

Level of performance corresponding to the percentiles
98-99 %ile = Very Superior
91-97 %ile = Superior
75-90 %ile = High Average
25-74 %ile = Average
9-24 %ile = Low Average
3-8 %ile = Borderline
2 nd%ile and below = Impaired

of March till the end of December 2022). The patient was motivated by different strategies to fight with the consequences of the illness, and she undertook additional activities (see: Table 2).

In the second neuropsychological examination, after completion of the entire program, the patient's verbal and non-verbal IQ increased significantly, and were higher than the norms. Improvement was also seen in nearly all cognitive functions, including immediate and delayed logical and visual recall, and the maintenance of a longer attention span (see Table 1).

Table 2. Activities undertaken by the patient (Pąchalska 2008)

Type of activity	Description of activity
Sleep	She worked on improving the conditions for getting good quality sleep.
Exercise	She undertook physical activity beneficial for her heart and lungs, and for her brain functioning.
Food	She took a well-balanced, healthy diet to give her body the nourishment needed for good health.
Family contact	She kept in touch with family members and friends via social media and later through direct contact, not only to improve her mood, but also to help her with thinking and memory.
Other beneficial activities	She read a novel, engaged in cognitively stimulating activities, listened to music, and tried to maintain a positive mental attitude.

Art therapy

The rehabilitation program took advantage of the patient's natural ability to copy and paint by providing her with appropriate material according to the principle of graded difficulty (cf. Pąchalska 2008). Fig. 2 presents selected drawings, showing the first steps in her return to drawing and painting. Initially, she drew mainly in pencil while lying in bed in a semi-sitting position. Her first attempt after her illness illustrates that she could not draw a straight line and was unable to lay out a face on a piece of paper (see Fig. 2A). During the first days of exercise, she drew various patterns, sometimes without noticing that she was putting them one sheet on top of the other, indicating an attention deficit (cf. Fig. 2 B).

At this time, the patienthad a very low mood, and lamented that COVID-19 had caused great havoc in her life. She put this into words as follows:

Using all my willpower, I tried to force my eyes to see properly and my hands to paint [...]. I lack the technique for painting, seeing the whole picture, my flashy colors [...] Drawing a face is damned difficult. Nothing in it stays in place, nothing holds its shape. Maybe I can get a believable shape now [...] In the past I felt confident seeing in my imagination and then on the board on which I painted a particular shape, now I feel more like catching a trout in the river using my bare hands [...] Everything is slipping away [...].Painting is my "survival school." I have to work a lot, because if I still don't know how to create, I'll die.

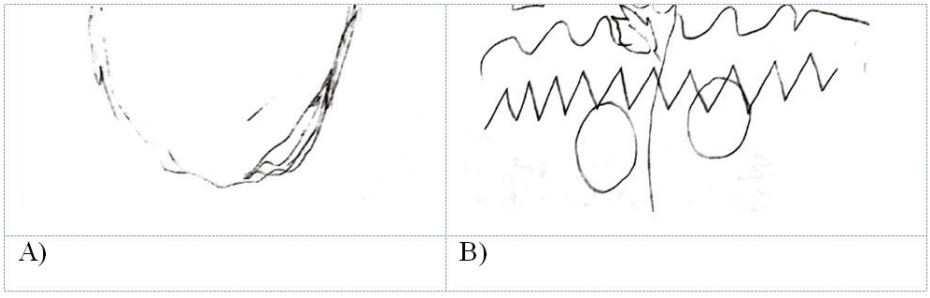

Fig. 2. The first steps in learning to draw and paint again
Source: author's ownclinical material

Faces in the artist's art

Faces and portraits, which she had previously painted in a very realistic manner, generally on board, had become very difficult for her. In her own words:

The face often shows what we ourselves are not aware of. However, critics and sensitive observers can read a lot from our faces [...]. I can't over emphasize the fact that painting faces causes me great difficulties. I don't always picture the face or mouth properly, and it requires additional preparation for painting, for pains taking sketching.

At the beginning of her first month of therapy, she noticed that although she was slowly recovering, she was unable to continue copying and painting pictures on the board due to the weakness of her hands. After two months of intensive training, several hours a day, she drew a copy of the Miraculous Image of the Transfiguration of the Lord from the Collegiate Basilica of St. Margaret in Nowy Sącz. The execution of this work was a breakthrough in her healing process. The artist said that with this drawing, which is a copy of a unique artwork in Poland (see Fig. 3); in her own account, it was not so much because of the story it contains, as because of the iconographic content presented, that she is expressing her thanks to the Lord that she survived such a severe illness.

After four months of treatment, the artist is now using brighter colors, and the variety of colors is greater. The most successful work in this regard was a copy of Leonardo daVinci's painting, "Lady with an Ermine," made from a postcard (the original of this painting hangs in the CzartoryskiMuseum in Krakow). Art ex-

Fig. 3. Copy of the Miraculous Image of the Transfiguration of the Lord from the Collegiate Basilica of St. Margaret in Nowy Sącz
Source: author's own clinical material

Fig. 4. Copy of Leonardo daVinci's painting, "Lady with an Ermine," made by the artist based on a postcard. Oil 60x90 cm
Source: author's own clinical material

perts believe that the painting is stunning and came from the brush of a talented artist, who herself was a loving person and an excellent mother of eleven children; this may have influenced the execution of the painting, which, unlike the original, allows emotional meaning to be read into this face (4). The painting delights and evokes positive emotions, as the face is undoubtedly beautiful.

Fervor of feelings in the artist's art

The artist particularly appreciated the ardor of feelings in art, expressed in Gustav Klimt's work *The Kiss*, among others. His works inspired her, and she made a reproduction of this work (see Fig. 5). From a neuroscience perspective, this is a valuable contributionto understanding how painters present emotions, as it allows people with brain damage, especially visual painters, to benefit from cultural heritage in the recovery process. Inspired by their cultural heritage, they sometimes add a new interpretation and even meaning to their works (cf. Pąchalska 2020).

Stories were also introduced to stimulate the artist's imagination. As an example, consider "The Story of the Muses," in which the ancient Greek poet Hesiod, author of the Theogony, speaking in the first person, describes how one day the Muses came to him as he was tending and talk to him. The patient became very interested in the content of this story, which she listened to several times, and then made a copy of the painting "Dance of the Muses with Apollo" from a postcard (see Fig. 6).

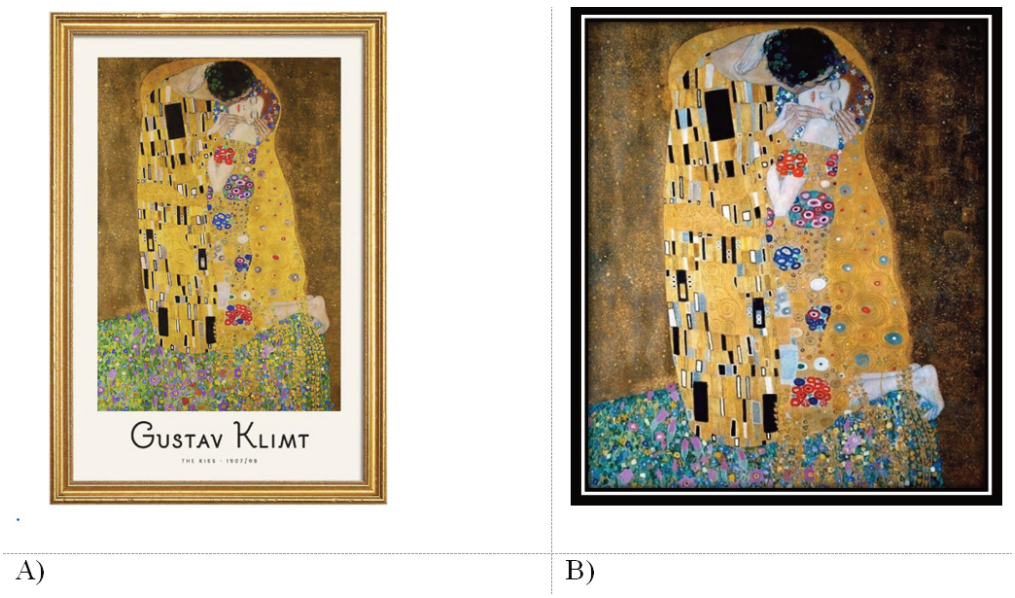

Fig. 5. Gustav Klimt "The Kiss"
A) Reproduction (poster) 100x100 (as an aid to painting).
B) A copy based on the reproduction of "The Kiss" painted by the artist 5 months after awakening from a pharmacological coma
Source: author's own clinical material

Fig. 6. A copy of the painting "Dance of the Muses with Apollo," made on the basis of a postcard 5 months after awakening from a prolonged post-Covid coma
Source: author's own clinical material

This type of therapy made the artist extremely productive, and she painted more than 200 different paintings, mostly on board. This allows for a detailed analysis of her work after surviving NeuroCOVID-19, and after awakening from a prolonged pharmacological coma, compared to her premorbid work. This analysis reveals a huge variety of subtle sequelae of the disease, most of which

can be explained by the breakdown of neuronal connections under the influence of the disease and the rebuilding of these connections in the process of art therapy and later in the process of neurotherapy. The richness of the subject matter presented in this artist's work is noteworthy.

Side effects of long term COVID-19

In August 2022, the artist's condition deteriorated and she stopped painting. She complained of headaches, sleep disorders, and recurrent, frequent replaying of the trauma experienced on ICU on waking (i.e., flashbacks involving recurrent memories of a traumatic event from her own past), as well as in her sleep (night terrors, nightmares). The neuropsychiatrist who consulted her found persistent, conscious avoidance of various types of stimuli associated with the traumatic event and a reduction in general reactivity (avoidance of thoughts, feelings associated with it), as well as a reduction in her hitherto very active social life and a slight neglect of activities of daily living, and above all an aversion to painting. In addition, she also found elevated levels of psychophysiological arousal, irritability, hypervigilance, occasional outbursts of anger, irritability, high propensity to anxiety, difficulty sleeping and sleep disturbances. As a result, she was given a diagnosis of PTSD with delayed onset as defined by DSM-5. In the literature, such a disorder is as among the symptoms of so-called long-COVID (Aknin 2021). Standard pharmacological treatment was administered**.**

NEUROPHYSIOLOGICAL TESTING

EEG recording

The electroencephalogram (EEG) was recorded with the Mitsar 21-channel EEG system, with a 19-channel electrode cap with tin electrodes that included Fz, Cz, Pz, Fp1/2, F3/4, F7/8, T3/4, T5/6, C3/4, P3/4, O1/2. The electro-cap was placed on the scalp according to the standard 10–20 system. Electrodes were referenced to linked earlobes (off-line), and the input signals were sampled at a rate of 250 Hz (bandpass 0.5–30 Hz). The ground electrode was on the forehead. Impedance was kept below 5 kΩ. The patient was sitting in a comfortable chair looking at a computer screen (17 inches) 1.5 meters in front of her. All recordings were made by the author of the present study. The ERP wave forms were averaged and computed off line, and trials with omission and commission errors were automatically excluded.

Behavioral task

The task consisting of 400 trials were sequentially presented to the subject every three seconds. Three categories of visual stimuli were used: (1) 20 different images of animals – referred to later as A; (2) 20 different images of plants – P; (3) 20 different images of people of different professions (presented together with an artificial "novel" sound), referred to as H. The trials consisted of presen-

tations of pairs of stimuli with inter-stimulus intervals of 1 second. The duration of stimuli presentation was 100 ms. We used four trial categories: A-A, A-P, P-P, and P-H. In the trials with A-A and P-P pairs, the first and the second stimuli were identical (physically the same). The trials were grouped into four sessions, with 100 trials in each. In each session, a unique set of five A stimuli, five P and five H stimuli was selected. Each session consisted of a pseudo-random presentation of 100 pairs of stimuli, with an equal probability for each category and each trial category (Kropotov 2016). The task was to press a button with the right hand to all the A-A pairs as fast as possible, and to stop pressing in response to other pairs. The patient performed 10 trials without recording to see if she understood the instruction. She rested for a few minutes after completing 100 trials. The stimuli occupied about 3.8° of the visual field around the center of the screen. The visual stimuli were selected to havesimilar 2D sizes and luminosities.

Artifact correction procedures

Eyeblink artifacts were corrected by zeroing the activation curves of individual independent components corresponding to eye blinks. These components were obtained by the application of Independent Component Analysis (ICA) to the raw EEG fragments as described in Kropotov (2016). Epochs with excessive amplitude of filtered EEG and/or excessive faster and/or slower frequency activity were automatically marked and excluded from further analysis. The exclusion thresholds were set as follows: (1)100 μV for non-filtered EEG; (2) 50 μV for slow waves in the 0–1 Hz band; and (3) 35 μV for fast waves filtered in the band 20–35 Hz. In addition, we visually inspected the recordings and excluded the remaining artifacts.

EEG spectra

EEG spectra were computed for Eyes Open, Eyes Closed and the GO/NOGO task conditions separately. The artifact free fragments of the EEG were divided into 4-second epochs with a 50% overlap. The Hanning time window was applied. The EEG spectra were computed for each epoch and averaged. The mean value and standard deviations for each 0.25 Hz bin were computed. For comparison of the EEG spectra before and after intervention, the t-test was used.

EEG-Neurofeedback

The artist received the most frequently used EEG-Neurofeedback – frequency/power neurofeedback with the use of 2 bipolar surface electrodes, called “surface neurofeedback” (Kropotov 2016). She received Theta/Beta, SMR training including (1), on C3, strengthening Beta1 and inhibiting Theta + inhibiting Beta 2, and (2) on C4, strengthening SMR and inhibiting Theta inhibition + inhibiting Beta, based on the international 10-20 system (see: Thompson & Thompson 2012). This was given after the diagnosis of PTSD (from the beginning of August till the end of November 2022), twice a week.

RESULTS

In spectra obtained before and after EEG-Neurofeedback, qEEG is characterized by frontal (middle) theta and occipital alpha. In the first study, there was an extensive occipital alpha at P4, chich disappears in the secondo study, after 20 sessions of EEG-Neurofeedback (Fig. 7). This signifies acessation of flashbacks, chich many scholars believe also signifies the alleviation of PTSD symptoms (Kropotov 2016).

Return to painting

After a month of EEG-Neurofeedback-supported therapy, the patient once again returned to intensive painting. She painted a copy of Gustav Klimt's painting ,"Portrait of Adele Bloch-Bauer" from a postcard after EEG-Neurofeedback therapy (Fig. 8). However, she says that the sleep problems are still persisting, though mitigated, and this has forced her to use smaller picture formats. Creativity often allows one to survive the disease and its various aftermaths. The artist has had to overcome various limitations related to the aftermath of the disease in the process of art therapy, including significant general weakness and weakness in her upper and lower limbs.

During hundreds of attempts with sketching and copying, the patient recovered almost all of her ability to perfectly copy works of art. Sometimes it is difficult to distinguish the copy she made from the original, sometimes it is smaller than original (see Fig. 9).

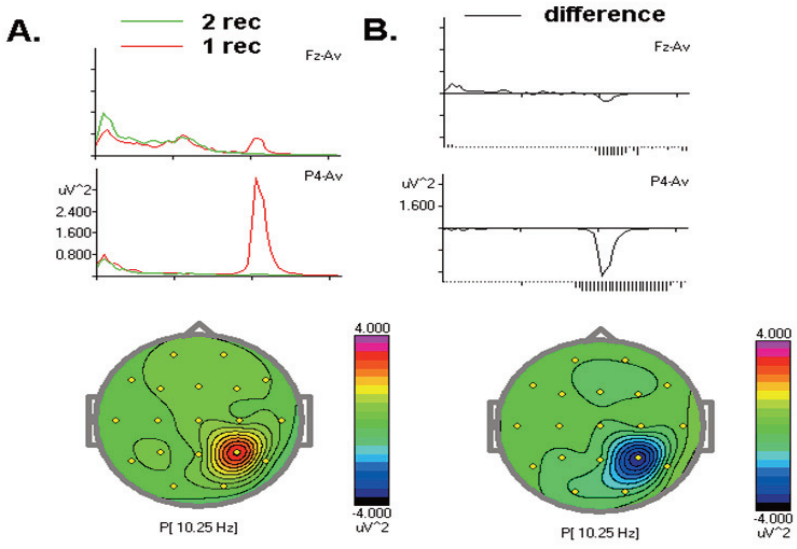

Fig. 7. Spectra obtained before and after neurotherapy
Source: author's own clinical material

Fig. 8. Copy of Gustav Klimt's painting "Portrait of Adele Bloch-Bauer": 40x50cm, made from a post-card after EEG-Neurofeedback therapy
Source: author's own clinical material

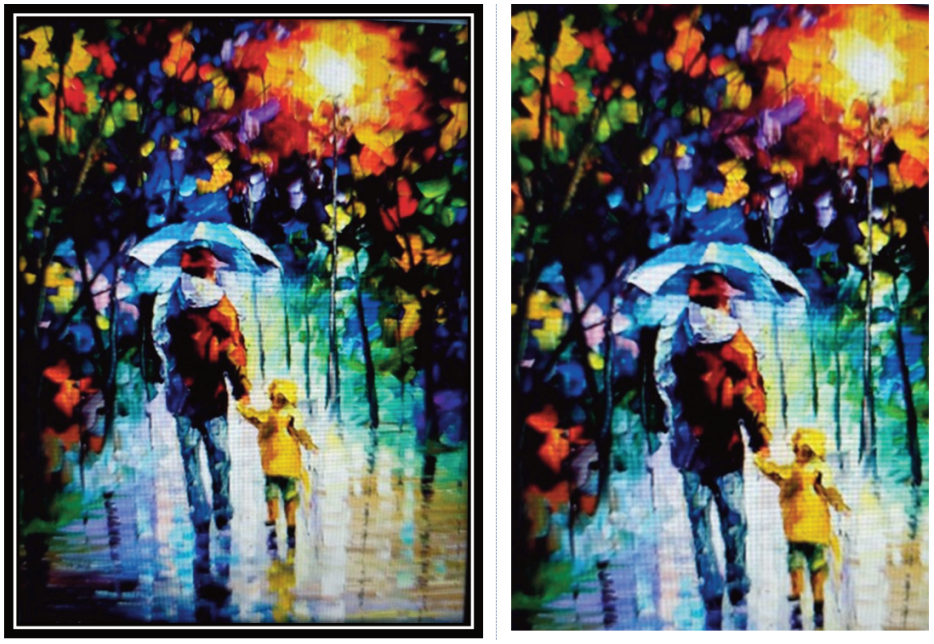

Fig. 9. A copy of Leonid Afremov's painting from the online gallery, from the Rain Painting series, based on a postcard Oil 60x90 cm at the end of therapy (in December 2022)
Source. author's own clinical material

However, the choice of a subject to copy is often related to her mood. Sometimes one copy differs from another with a smile or a sad face; at other times,her-mood is expressed by the subject matter of the work chosen for copying.

One of the biggest challenges for the artist was to make a copy of a painting by the American painter Lunda Hoyle Gill, entitled "Following in my fathers" (oil on canvas 90x120 cm), made in the process of art therapy (See Figure 10). She took up this challenge, even though it required considerable physical strength. Her satisfaction after completing this copy was immense. First of all, the patient regained her good mood, as she believed that she could paint large canvases again. The painting itself sold well at auction. It should be added that the copies of works made by the patientare always beautiful, and this makes her an artist with numerous orders for the works she has made.

There is also a portrait of one of her daughters as a model with natural hair (Fig. 11). The artist was inspired by the natural beauty and inner strength of this lovely woman, who groomed her at home, operated her ventilator at home, and did many rehabilitation exercises. The artist chose a limited color palette to simplify yet emphasize her daughter's identity by painting elements of her folk costume (garland and flowers). She used deep green and blue (background), transparent red oxide for flowers, white for scarf and black for hair, and other colors. Finally, she added other colors for details. This limited palette gave her so much freedom that one can only enjoy the value and warmth of the painting. It was, she says, a fantastic experience. It should be noted that she used lot of imagination. A new style was born, which is, as we know, the definition of creativity (Brown 2017).

Fig. 10. A copy of a painting by Lunda Hoyle Gill, entitled "Following in my fathers" (Oil on canvas 90x120 cm), made on the basis of a postcard at the end of therapy (late November 2022)
Source: author's own clinical material

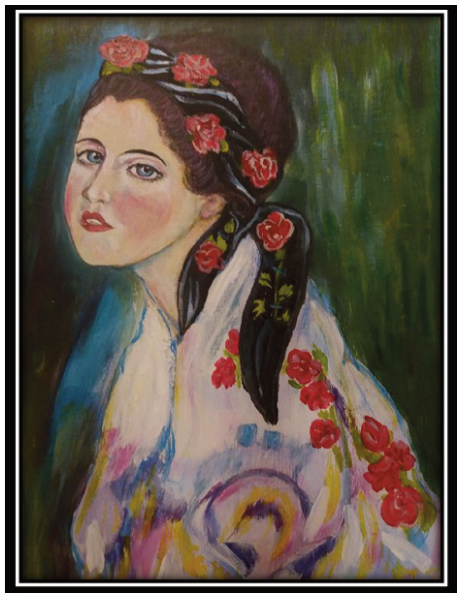

Fig. 11. Portrait of daughter painted by the artist, Oil on canvas 90x120 cm (late November 2022)
Source: author's own clinical material

It should be added that the patient is fully independent after completing the proposed therapy program. Moreover, she uses mass media, the computer (which she learned to use during her illness), drives a car, organizes parties, for which she prepares wonderful new dishes. The artist often makes jokes in original ways such as:

I cook rich dishes and bake various kinds of cakes. But as for a "pinch of salt," for me, that's a unit of measurement that remains unidentified.

This should probably be taken as an indication of the patient's sense of humor. The artist also supports her family and other patients who suffer from the disease with good advice and gifts. Now she is painting other people from her large family, and friends. Her faith in God, to whom she is grateful for saving her life, has strengthened. She expresses this in prayer and other fervent religious practices.

DISCUSSION

The course of the disease, treatment and rehabilitation presented in this case study of a 67-year-old artist is interesting, and although some aspects may not be fully understood, it is nonetheless informative. It is not easy to discuss the various stages of this process, as knowledge about the SARS-Cov-2 infection itself and NeuroCOVID-19 is still being assembled, expanded and modified. There are many scientific questions still unanswered. The most important of these may well be this: why does only a small percentage of those infected with SARS-CoV-2 develop the disease in its severe form? Most infections are pauci- or asymptomatic (Sutton et al. 2020). Some authors have found that the most

important predisposing conditions are hypertension, obesity, cardiovascular disease, diabetes or older age (Kenyon 2020; Sutton et al. 2020; Richardson et al. 2020). Increasing evidence suggests that the reason why only certain chronic diseases predispose themselves to severe disease is that they are associated with a pro-inflammatory state and an imbalance between the pro-inflammatory angiotens in converting enzyme-1 (ACE1) and anti-inflammatory (ACE2) axes in particular (Henry et al. 2020; Sriram & Insel 2020). The chronic diseases associated with COVID-19 are typified by a dominance of the ACE1 axis, which promotes vasoconstriction, as well as inflammatory, oxidative and fibrotic tissue damage. A sedentary, excess-calorie life style results in the same proinflammatory ACE1 bias (Migdalis et al. 1990), as does aging without staying fit (Ferrucci & Fabbri 2018). The severity of COVID-19's course in the artist described here may indeed have been the result of some of these factors, since she was older, had a sedentary, excess-calorie life style, and suffered from obesity. She also suffered from untreated hypertension and cardiovascular disease.

Another important question to ask here is why mechanical ventilation and sedation in the intensive care unit (ICU) had an impact on the late recovery of consciousness in the patient. We know that the pandemic has created a large population of patients post SARS-CoV 2 infection who have contracted severe COVID-19, and who require mechanical ventilation and sedation in an intensive care unit (ICU). We also know that late recovery of consciousness after such treatment, as stated by Schiff and Brown (2022), is a common and puzzling phenomenon. There are many causes that may lead to this situation. It is worth listing the most important factors that can cause a late recovery of consciousness. These include:

acute respiratory distress syndrome (ARDS), a potentially fatal condition, in which the alveoli fill with fluid, which diminishes the lungs' ability to provide the vital organs with enough oxygen. ARDS entails severe inflammation of the lungs, but the main problem is that it makes portions of the lungs unusable. As a result, oxygen deprivation may develop, affecting the intricate neural networks of the brain, and impeding and upsetting the flow of information.

neurotropism of SARS-CoV-2 which can lead to direct brain injury. SARS-CoV-2 spike protein S1 has a strong affinity for the human ACE2 receptors, which are expressed on neurons. The virus may reach the brain through a hematogenous route or retrograde axonal transport (via the olfactory nerve).

pro-inflammatory state, in which infection has the potential to trigger ischemic strokes. Up to a third of ischemic strokes are preceded by infection with SARS-CoV-2 (Parry et al. 2020), which can evoke stroke through a range of potential mechanisms. The most frequent form is the rupture of vulnerable atherosclerotic plaques in the presence of a severe pro-inflammatory state, which may lead to thromboembolic events in severe COVID-19. The massive release of cytokines in severe COVID-19 may result in a breakdown of the blood-brain barrier (BBB), predisposing to brain injury.

dyselectrolytemia, resulting from the hypokalemia and hyponatremia commonly seen in patients with severe COVID-19, correlating with the degree of

renal injury. Hyponatremia causes diffuse brain edema, whereas rapid correction of hyponatremia is linked to demyelination.

moderate hypoxic neuronal damage during treatment with mechanical ventilation and sedation in the intensive care unit (ICU), including paralyzing agents, on top of long-term sedation such as midazolam, or opiates such as fentanyl or morphine, which could also be paralyzing agents, a suspicion which has been confirmed through neuroimaging findings in these patients (Parry et al. 2020).

Hypoxic ischemic encephalopathy resulting from acute hypoxemia. Prolonged hypoxia may induce demyelination or produce white matter microhemorrhages. Prolonged hypoxemia leads to oligodendroglial cell injury. Oligodendroglial cells constitute the myelin sheath of nerve cells, and their death causes demyelination of the white matter of the brain. Prolonged hypoxia also causes BBB disruption, leading to leaky capillaries, which in turn can produce microhemorrhages.

neurological dysfunctions, which have been reported in many patients with a severe course of COVID-19[2], as an early consequence of virus-induced brain damage (Mao et al., 2020; Gutiérrez-Ortiz et al. 2020; Mohammedi et al. 2020; Morassi et al. 2020; Pachalska et al 2021).

Like many other patients, the artist showed no signs of premorbid structural brain injuries, and had enjoyed full cognitive functioning prior to the illness. She developed a severe course of COVID-19 with ARDS: 80% of her lungs were unusable, so probably her brain did not receive enough oxygen, especially during pronepositioning. She may also have had moderate hypoxic neuronal damage during the long 13-weeks of treatment with mechanical ventilation and sedation in the ICU. Therefore, she may have developed moderate hypoxic neuronal damage. These factors could have been the main causes of the side effects we observed in our patient: that is,

*short-term side effect*s, such as neurocognitive dysfunction, including attention, memory, and dysexecutive deficits (see also Pachalska et al. 2021). Such neurocognitive dysfunctions have previously reported in the literature (Rogers et al., 2020; Varatharaj et al., 2020; Pąchalska et al. 2021).

long-term side effects, such as various physical and mental symptoms, including PTSD, which lasted for months (see: Table 3). According to the Centers for Disease Control and Prevention (CDC), individuals diagnosed with COVID-19 or NeuroCOVID-19 can display the some or all of the long-term side effects listed in Table 3 (Nuzzo et al. 2021).

Several studies have indicated that in many patients such side effects can last for weeks or even months following SARS-CoV-2 infection and severe COVID-19 (see also Aknin et al. 2021), indicating that patient observation should be maintained over a long period of time (Stueck 2021).

Why did the artist have problems with the creation of art work?

[2] Neurological injury has been reported in the past associated with other coronavirus infections, such as SARS and Middle East Respiratory Syndrome, with the nucleic acid of these coronaviruses retrieved in the cerebrospinal fluid of infected patients and also in their brain tissue on autopsy, suggesting neurotropism and direct damage as the underlying mechanism of brain injury (Morassi et al. 2020).

Table 3. List of long-term side effects (according to CDC) developed by the artist

Long-term side effects(according to the CDC)	Developed by the patient
Tiredness	Yes
shortness of breath	Yes
Coughs	Yes
joint pains	Yes
chest pains	Yes
brain fog	Yes
depression	Yes
muscle pains	Yes
headaches	Yes
heart palpitations	Yes
hair loss	Yes
loss of taste/smell	No
anxiety	Yes
PTSD	Yes

Source: own elaboration on the basis of Parry et al. (2020).

Qualitative changes in the works executed by professional artists as a direct consequence of mental illness constitute an intriguing and already partially neuroscientifically recognized phenomenon (Pąchalska 1986; 1999; 2019, 2021; Kaczmarek 1991; Bäzner and Hennerici, 2007; Piechowski-Jozwiak & Bogousslavsky 2013). These are generally associated with the site and depth of brain damage, but also with any functional changes in the brain, as is the case, for example, in patients after infection with SARS-CoV-2 and NeuroCOVID-19. This is because different areas of the brain and their neuronal connections, which are responsible for the creative skills found in various art forms, such as music, painting, literature and cinema, can be damaged. In the case of visual art, these include basic motor skills (such as movement coordination), visuospatial processing, emotional processes, socio-cultural context and creativity (cf. Pąchalska 1999; Pąchalska, Kaczmarek and Bednarek 2020). There may also be changes in the creative workshop, the way of creating or the artistic style itself, which leads, for example, to surprisingly innovative workshop solutionsin some people who display an initial loss of artistic creativity (cf. Pąchalska 2022). Neurological diseases can also sometimes modify artistic style and lead to innovative features despite an initial loss of creativity. Therefore, the relationship between artistic creativity and brain diseases is particularly complex (cf. Mazzucchi et al. 2003; Bäzner and Hennerici, 2007; Pąchalska 2022). Our patient displayed perceptible changes in her creative workshop, the way she created, and even her artistic style, which was related not only to the course of the disease, but also to the pharmacological coma. This began with an initial loss of creativity: she could hardly paint anything. The most important immediate reason for this was the great weakness of the upper extremities, but there were also neurocognitive disorders related to the complexity of brain dysfunction. It is worth recalling at this point the role played by different areas of the cerebral cortex in the normal course of individual mental functions:

- The frontal lobes are associated with a number of neurocognitive and neurobehavioral functions that provide, among other things, planning and control of the smooth course of action (initiating, inhibiting and changing the mode of action).
- The temporal lobes are associated not only with understanding verbal utterances, but also with other functions, such as memory, perception and emotion.
- The parietal lobes are responsible not only for sensation, but also for visuospatial functions, including the association of stimuli,
- The occipital lobes are associated not only with visual perception, but also with spatial organization.

From the point of view of microgenetic theory, one should also add here the processes taking place in subcortical structures, which also exert an influence on the proper course of mental functions, and especially emotional and motivational processes and related attitudes, desires, and needs (cf. Pąchalska, Kaczmarek and Kropotov 2021). However, regardless of whether we adopt a bottom-up perspective (from receptors to the center/brain) or top-down (from the center/brain to the periphery), the important thing is that the image of reality that is formed in our mind is only a model of it. After all, the ancients already emphasized that "the senses lie," and the way the senses "trick the brain" is related to individual factors in both health and disease (Pąchalska 2007a, b, c). The modification of neuronal connections related to the disease, as well as the goal-oriented process of neuropsychological rehabilitation, undoubtedly influenced the process of creating our patient's artwork. However, after six months of neuropsychological rehabilitation, the patient deteriorated, and developed PTSD.

We will not find an easy answer to the question as to why she developed PTSD. It is not out of the question that in the moments when she hallucinated she had flashes of consciousness and saw people dying in the ICU or heard the agitated voices of doctors resuscitating patients dying next to her. We do know, however, that it is a complication that can occur in the short term and in the long term, in so-called long COVID (Aknin et al. 2022; Pachalska et al. 2021). An extensive Medline search found that most reports confirm the existence of information processing disorders in patients with PTSD (Parry et al 2020; Talukder et al 2022). Event-related potential (ERP) testing is the main tool in any study of real-time millisecond information processing (Kropotov 2016). Based on the available data and our own research, we suggest that abnormalities in QEEGs and ERPs may lead to a better understanding of the mechanism of PTSD, in which individual symptoms overlap (Pachalska et al 2021).

Why did the artist achieve good results in the proposed neuropsychological therapy supported by EEG-Neurofeedback?

The patient's improvement may be ascribed to several factors:

The goal-oriented neuropsychological rehabilitation program, supported by EEG-Neurofeedback. This is an approach that uses guided practice on structured tasks with the direct aim of improving or maintaining cognitive abilities, as well as emotional and behavioural control. This program is probably associated

with small to moderate positive effects on global cognition and verbal semantic fluency at the end of treatment, and these benefits appear to be maintained in the medium term (Pąchalska 2008; Bahar-Fuchs et al. 2019).

EEG-Neurofeedback with the proper protocol for training directed toward the patient's needs.[3] I chose theta/beta, SMR training on C3,which included (1), strengthening Beta1 and inhibiting Theta + inhibiting Beta 2, as well as (2) strengthening SMRand inhibiting Theta inhibition + inhibiting Betafor C4). In the subject literature we can find suggestions that theta/beta SMR training on C3 may improve neurocognitive functions, the speed of intellectual processes, speech fluency, attention concentration, learning abilities, motivation to action, and increased motivation to undertake intellectual effort and maintain a good work pace. Training at C4 may reduce anxiety, agitation and aggression, calm the patient, and increase self-control, relaxation, spatial orientation and a sense of satisfaction (Thompson & Thompson 2012; Mohammedi et al. 2015, Aron et al. 2016; Kropotov 2016, Mroczkowska et al. 2018). EEG-Neurofeedback is considered to be operant conditioning of neural oscillations, in which the brain is trained to gain control over specific EEG parameters by real-time visual or auditory feedback. The desired brain activity is reinforced, and undesired brain activity is inhibited. Several studies have supported the conclusion that EEG- Neurofeedback training is a promising treatment for various disorders (Thompson & Thompson 2012; Mohammedi et al. 2015, Aron et al. 2016; Kropotov 2016).

Adequate motivation of the patient to exercise, while actively searching for various ways of coping with the late effects of SARS-CoV-2 infection and ongoing neuroCOVID-19. Motivation and engagement are important factors associated with therapeutic outcomes in cognitive training (Best et al. 2020; Makransky et al. 2007).Besides medical treatment, she practices a healthy life style to improve her situation (cf. Pąchalska 2008).

Art therapy, which was given with the goal-oriented neuropsychological rehabilitation program, be a method that promotes the recovery of visual artists who have lost the ability to paint (Braus & Morton 2020; Pąchalska 2022). Research using various neuroimaging methods of brain function suggests that art therapy can be a reward for the patient (Pąchalska 2022). Our brains calculate the value of a reward according to an accepted value system. This phenomenon is translated into action. This is managed, among other things, by neuronal circuits in the brain called the "reward system." Therefore, art therapy is a strengthening of the reward system and a weakening of the punishment system (see Fig. 12).

To support these views, one can cite neuroimaging studies involving people who viewed beautiful paintings, in which it was found that not only was the right hemisphere of the brain activated, but also the reward system (Heilman 2016).

[3] Neurofeedback is a method of neurostimulation that promotes the development of cognitive processes, stabilization of emotional processes and behavior modification. Although the number of randomized placebo-controlled studies on EEG-neurofeedback and its effects on neurocognition is limited, the research results obtained are promising (Vollebregt et al. 2014). Indeed, improvements in the parameters of attention and working memory, as well as executive functions are observed with the proper placement of electrodes, the correct selection of points for stimulation, and the use of appropriate therapy protocols (relaxation and cognitive) (cf. Kropotov 2016).

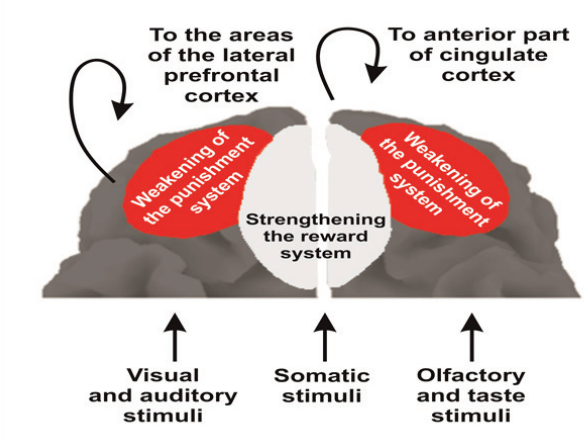

Fig. 12. Strengthening the reward system and weakening the punishment system
Source: Pąchalska 2019, modified

Similar activation was also found in people who painted beautiful pictures (cf. Pąchalska et al. 2014). Moreover, prefrontal area activity was also found to increase when subjects were presented with religious-themed stories related to tradition, so long as they believed the stories and religious episodes presented to them (Harris, Kaplan, Curiel et al. 2009). The activation gothicised mainly the ventral tegmental area of the frontal lobes, which have numerous connections to the paraventricular nucleus, which has a close relationship with the reward system (Kropotov 2016; Pąchalska 2022). Obviously, the artist described here, who painted many copies of the Miraculous Image of the Transfiguration of the Lord from the Collegiate Basilica of St. Margaret in Nowy Sącz (see: Fig. 13) and therefore repeatedly viewed the beautiful works she had made, showed them to other people and told them about them, and believed that it was the Lord Jesus who had miraculously saved her life, had to activate the reward system in herself, and therefore the execution of these works was a breakthrough in her healing process.

We know from neurophysiological studies that the brain regions responsible for the reward system use the neurotransmitter dopamine to communicate (Kropotov 2016). Dopamine-producing neurons in the ventral tegmental area (VTA) communicate with neurons in the nucleus accumbens to assess the value of a reward and motivate us to receive it. Neurons in the various brain areas that make up the reward system also communicate via dopamine. The creativeprocess in thisartistcontributed to the release of dopamines, whichalsostrengthenedreward-relatedmemories. Dopamine signaling in areas of the brain that process emotions (the amygdala) and regions involved in planning and reasoning (the prefrontalcortex)createdemotionalassociations with rewards. Thus, the process of creation also contributed to strengthening synaptic connections in the

Fig. 13. Copies of the Miraculous Image of the Transfiguration of the Lord from the Collegiate Basilica of St. Margaret in Nowy Sącz at the artist's desk
Source: author's own clinical material

hippocampus, improving memory and learning processes, thanks to which the artist's neurocognitive functioning improved (see also Gazzaniga 2013).

Brown (2017) believes that it is not the reward itself, but the expectation of reward that most strongly influences emotional responses and memories. Reward learning occurs when we experience something unexpected – that is, when the actual reward is different from what we would otherwise anticipate. Dopamine signaling increases if the reward is great er th ananticipated and decreasesif the reward is less than expected. Correctly predicting a reward does not change dopamine signaling, because we are not learning anything new. In the artist's case, the reward for creating (especially copies of works by prominent artists) was high and not expected. Indeed, these works have achieved great popularity on the market, especially among collectors. The prices of this artist's works continue to rise, which she did not anticipate. Accordingly, the dopamine signaling in her brain is increasing, which is why she feels happy.

Who's in charge, me or my brain?

Gazzaniga (2013) believes that it is important to pay attention not only to brain function, but also to the entire Self system. We know, based on studies of people with a variety of brain damages, that there is a greater or lesser breakdown of the Self system (Pąchalska 2007c; 2019). The same thing happens in patients who have been treated for severe COVID-19 in the ICU, especially after a pharmacologically induced coma (Pąchalska et al. 2021), which is also the case for the artist presented in this case study. It is therefore necessary to assist not only in treating the immediate aftermath of the disease, but also in rehabilitation measures that will help to reintegrate the Self system. In the goal-oriented therapy program proposed to our patient, carefully selected to meet her needs, such reintegration was achieved. This was made possible not only by improving cognitive, executive and emotional functions, but also by changing a number of other factors:

1. the self-concept in the course of action, especially in the process of painting;

2. the model of the world and its modification as a result of the recovery of the ability to create, and the related life events occurring in her social environment;
3. the restoration of the sense of subjectivity, that is, the independent action of the Self system;
4. the modification of the sense of identity, in connection with changes and life events occurring in the environment.

In order for the reader to better understand the process of the artist's illness and recovery, it is worth recalling what we mean by the Self System (see: Fig. 14). In a previouswork I have presented in detail the whole concept of this system (Pąchalska 2007c; 2019). This includes:

1. The individual self, which consists in:
   A). *The objective self* (known), understood as the organism, i.e. in Goldstein's (1995) approach the body, together with its states and processes occurring in it. The objective self has consciousness, but it lacks self-awareness and meta-consciousness (awareness of mental operations by its own subject). In Obuchowski's (1993) approach, the objective self does not express its own thoughts, but acts according to ready-made schemes: it is not the aut-

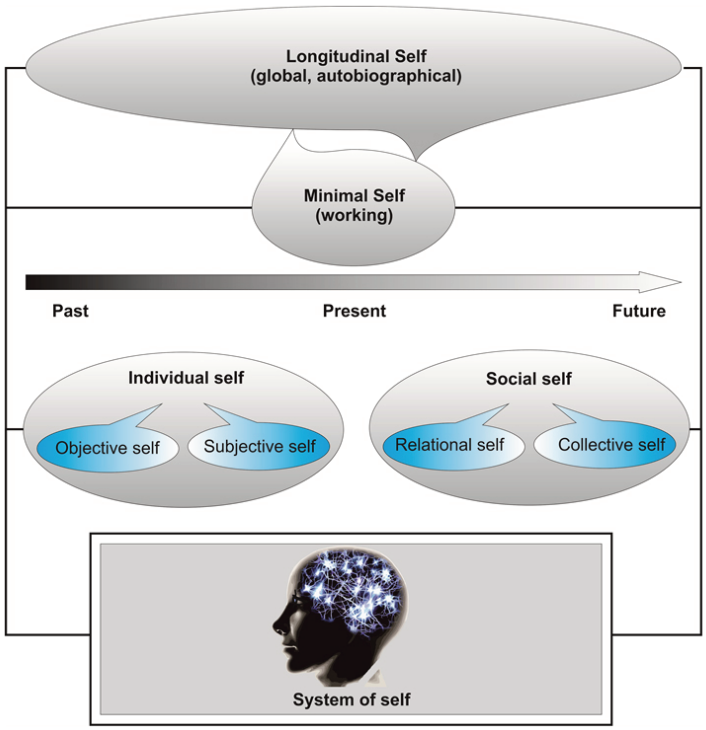

Fig. 14. Modified process model of the system of self in time, including minimal (working) and longitudinal (autobiographical) self
Source: author's own work

hor of itself. As soon as one realizes the existence of the outsider world, one's objective self also becomes the object of perception. This process enables the subjective self to be formed.

B). *The subjective self* (cognitive), having consciousness, self-awareness and meta-consciousness, enabling one to know oneself and act in accordance with one's own needs and values, as well as the requirements of the environment. In Obuchowski's view (op. cit.), the subjectivepersonis a "Self-Author," who has a sense of separateness, autonomy, insight (introspection), the possibility of self-assessment and self-control and creativity (see Pąchalska 2008). The subjective self conditions the appearance of individual identity.

2. The socialself, chich includes:
   A).*the relational self*, understood as an image and description of the I-You dyad (interactions), from an individual and social perspective, taking into account relationships with other import ant people and social groups around which, according to Richard Brown (1987), social identity develops.
   B).*the cultural self*, understood as an image and description of the I-You-Them triad from an individual and social perspective, including the nesting in the culture or subculture of a given social group (including religious one) around which cultural identity develops.

The case study presented above shows that neurofeedback may be an additional technique useful in the self-regulation of brain function after SARS-CoV-2 infection and undergoing neuroCOVID-19 when compared to standard neuropsychological therapies. Almost all the short and the long-term side effects of neuroCOVID (including the PTSD) were reduced in severity. The artist showed marked improvement and was able to return to painting. The artwork she made after her illness is in high demand with art collectors, which has improved the patient's quality of life.

Of course, even the best rehabilitation program would not have enabled the full reintegration of the Self system without the patient's motivation and enormous commitment, which was only possible because she wanted to return to painting, which gave meaning to her life. The return of the ability to paint undoubtedly strengthened the therapy's efficacy, by diverting her thinking from her poor physical and mental state, giving her great satisfaction, and thus stimulating her reward system. It became possible to reintegrate her system of Self, both individual and social, with a special focus on the cultural Self, including the religious Self. The artist says she has not only regained a sense of life, but also became a better and happier person after her illness, both in life and in her creative work.

CONCLUSIONS

Goal-oriented neuropsychological rehabilitation, with art therapy, supported with EEG-Neurofeedback administered for a visual artist with PTSD with delayed onset (as defined by DSM-5) resulting from infection with SARS-CoV-2, followed

by severe neuroCovid symptoms and the sequelae of long-term pharmacologically-induced coma, canbe helpful in the reduction of short term side effects, such as neurocognitive dysfunctions (attention, memory, dysexecutive symptoms) and long-term side effects, such as various physical and mental symptoms, including PTSD. It can be also helpful in the reintegration of the Self System.

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