

RESEARCH HIGHLIGHTS

The effects of coloring therapy on patients with generalized anxiety disorder

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Abstract

Generalized anxiety disorder (GAD) has harmful effects on physical and mental health and quality of life. Coloring therapy has been reported to have a positive effect on improving patient anxiety and depression. But there are no reported clinical trials examining their effectiveness as a treatment for GAD. This study was planned to evaluate the effectiveness of coloring therapy combined with conventional therapy in improving anxiety, depression, and positive and negative emotions with GAD. This randomized controlled study comprising 88 GAD patients was selected for intervention in different wards. The control group ($n = 45$) was given conventional antianxiety medication and physical therapy, and the experimental group ($n = 43$) received coloring therapy combined with conventional therapy. The Self-Rating Depression Scale, Self-Rating Anxiety Scale (SAS), Hamilton Depression Scale, Hamilton Anxiety Scale (HAMA), and Positive and Negative Affect Scale were assessed in both groups before and 3 weeks after the intervention. After the intervention, there were statistical differences in intra- and inter-group comparisons of anxiety, depression, and positive and negative mood scales in the experimental and control groups ($p < .05$). The minus in anxiety/positive emotions pre- and postintervention in the experimental group was statistically significant compared to that in anxiety/positive emotions pre- and postintervention in the control group (HAMA: $d = 1.45$, 95% confidence interval [CI] (0.34, 2.57), $p = .011$; SAS: $d = 3.87$, 95% CI (1.73, 6.00), $p = .001$; positive: $d = 1.76$, 95% CI (0.17, 3.34), $p = .030$). The minus in depressive/negative emotions pre- and postintervention in the experimental group was not statistically significant compared with that in depressive/negative emotions pre- and postintervention in the control group ($p > .05$). For GAD patients, adding coloring therapy based on conventional drug therapy and physical therapy can not only reduce depression and negative emotions but also have better effects on reducing anxiety and improving positive emotions than conventional therapy.

Bosomtwe Samuel and Hongmei Wang should be considered co-first authors who contributed equally to this work.

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KEYWORDS

anxiety, coloring therapy, depression, generalized anxiety disorder

1 | INTRODUCTION

Generalized anxiety disorder (GAD) is a persistent, scenario-independent disorder with worry psychological characteristics as a core, including subjective feelings and somatic symptoms.^{1,2} GAD is a clinically common chronic disease, with an annual prevalence of 1.9%–5.1% in the general population and a lifetime prevalence of 4.1%–6.6%. Its comorbidity rate is high, especially with depression, of 45.7%–70.0%.^{3,4} Studies have shown that persistent and recurrent anxiety and depressive symptoms can seriously affect the psychological health and quality of life of patients with GAD, increasing their risk of suicide and decreasing disability loss life years, thus imposing a serious psychological and economic burden on individuals, families, and even society.^{5,6} Therefore, it is of great clinical practice and social significance to seek more cost-effective treatments according to the psychological characteristics of patients with GAD.

Currently, GAD field studies have extensively discussed the pathogenesis of GAD in terms of genetic factors, neurostructural pathology, structural brain abnormalities, neurobiochemical abnormalities, immune system abnormalities, and endocrine system alterations,⁷ but a unified understanding has not yet been formed due to its intricacies. In the past clinical treatment, GAD was mainly treated with a combination of pharmacological, physical, and psychological therapies, due to difficulties such as long duration and easy recurrence. Of these, psychotherapy is an indispensable adjunct in the treatment of the disease, which can enhance the clinical treatment effect; significantly improve the anxious state of patients; and provide improvement in the disease, mainly including cognitive-behavioral therapy, relaxation training, kinetic therapy, interpersonal psychotherapy, and Morita therapy.⁸ However, most of the current psychotherapeutic tools still have poor cost-effectiveness ratios, so the increasingly critical global situation requires immediate new psychotherapeutic methods with short treatment courses, low cost, and low relapse rates. Research studies^{9–11} have shown that coloring therapy is a new treatment method in which patients can express their emotions through colors and patterns. It can provide psychological support for patients, reduce anxiety and depression, and help divert patients' attention from anxiety events. Compared with other psychotherapies, coloring therapy is not related to objective factors such as patients' cognitive ability, language, age, and drawing skills, and is favored by researchers because it is time saving, safe, efficient, and free from site constraints. However, research has been performed on coloring therapy in China, especially, further research on its practical application field and economic benefit ratio is required. Therefore, based on the comprehensive analysis of relevant research results at home and abroad, this study applied coloring therapy to GAD patients; assessed patients' psychological conditions pre- and postintervention; and analyzed and compared

the improvement in patients' anxiety, depression, and positive and negative moods to further study the mechanism of action and application value of coloring therapy in the treatment of GAD to provide new ideas for seeking more optimal psychological treatment.

2 | METHODS

2.1 | Study design

This study was a randomized controlled trial. It was conducted from January 2020 to December 2020. The study was approved by the medical ethics committee of our hospital. Participants could withdraw from the study for any reason at any time.

2.2 | Participant selection

2.2.1 | Inclusion criteria

Patients with the following criteria were recruited for the study: (1) patients who met the diagnostic criteria of the *International Classification of Diseases* (ICD-10) and were first diagnosed with GAD and hospitalized; (2) Hamilton Anxiety Inventory (HAMA) ≥ 14 points and Hamilton Depression Inventory (HAMD), 24-item version < 35 points, both in right-handedness; (3) age: patients aged 18–65 years; (4) education level: elementary school and above; and (5) study subjects and their families provided informed consent to participate voluntarily and signed an informed consent form.

2.2.2 | Exclusion criteria

The reasons for exclusion were as follows: (1) patients with other mental disorders, such as major depression, schizophrenia, panic disorder, and Parkinson's disease; (2) patients with serious heart, liver, kidney, and other organ diseases; (3) patients who could not cooperate with treatment or whose condition was unstable; (4) patients with eye diseases or color blindness that was not suitable for coloring therapy; (5) patients with hand injuries or disabilities that were not suitable for coloring activities; and (6) patients who were receiving other system psychological counseling or treatment.

2.2.3 | Dropout criteria

The reasons for withdrawal included patients who withdrew voluntarily for various reasons during the study.

2.3 | Setting

The patients were recruited from the department of a psychiatric tertiary care hospital. According to the post study, the size of this study was calculated by G*power, and the appropriate sample size was calculated as 80 patients. Finally, a convenient sample of 96 patients with GAD was selected from two wards for the study, 48 patients from January to June 2020 were included as the experimental group, and 48 patients from July to December 2020 were included as the control group. To prevent contamination, the experimental and control groups were not in the same ward.

2.4 | Intervention

2.4.1 | Control group

The control group received conventional treatment and nursing for GAD, in which treatment included pharmacotherapy with the same anxiolytic mechanism and physical therapy with transcranial magnetic stimulation and low-frequency pulsed current stimulation. The nursing in the control group included nursing routines, symptomatic care, and psychological care for patients with GAD. The intervention period was from inclusion in this study to 3 weeks after enrollment.

2.4.2 | Experimental group

The experimental group added coloring treatment to the control group.

Forming a research team

The implementation of the coloring therapy was a collaborative effort by the study team, which comprised two chief psychosomatic physicians, two attending psychosomatic physicians, two associate chief nurses, two charge nurses, two nurse practitioners, and two psychiatric nursing graduate students. Of these, two chief psychosomatic physicians and two deputy chief nurses performed strict quality control of the study protocol; two attending psychosomatic physicians assessed the anxiety, depression, and positive and negative moods of patients in both groups using psychometric scales before and 3 weeks after the intervention; two postgraduate students were responsible for the entire process of protocol construction and application, data collection, and effect evaluation; two charge nurses assisted the two postgraduate students in the implementation of the intervention protocol; two nurse practitioners assisted the two postgraduate students in data collection and effect evaluation.

Preparation before coloring therapy

1. Develop a coloring therapy protocol. Initially, we developed an intervention plan based on evidence. Then, we determined the intervention protocol by expert consultation and pretesting.

2. Train a team. The two graduate nursing students from the study team trained the team members according to the study protocol. The training involved a combination of classroom training and bedside practice; the training lasted for 3 weeks, twice a week, and lasted 90 min each time.
3. Prepare the tools needed for coloring therapy. The team leader prepared the tools needed for coloring therapy, including a 32-page coloring book for adults and 24 color pencils (lemon yellow, egg yellow, skin color, orange yellow, orange red, big red, light red, light pink, dark pink, purple red, purple, sky blue, ultramarine, light blue, grass green, light green, dark green, rich green, ripe brown, brown, dark brown, gray, black, and white) (Figure 1).
4. Intervention frequency. Duration of color application: 30–120 min five times per week for 3 weeks.

Implementation of coloring therapy

The research team's nurses and psychiatric nursing graduate students selected the research subjects according to the patients' medical records and the inclusion criteria of this study. Next, the attending physician of the research team evaluated the patients' anxiety, depression, and positive and negative emotions. Then, the nurses and nursing graduate students of the research team guided the patients to choose their favorite picture book patterns and colors to color the picture books according to the patients' condition and degree of cooperation in the patients' treatment interval. During this period, we did not interfere with the patients' choice of patterns and coloring intentions; kept the environment quiet, comfortable, and bright; closely observed the patients' emotions and vital sign changes; and did not interrupt the patients' coloring activities unless there were special circumstances.

To ensure the homogeneity and standardization of the implementation of coloring treatment, the principal investigator provided coloring treatment guidance to the members of the research team any time and promptly resolved any doubts by consulting literature, consulting relevant experts, and holding research group meetings.

2.5 | Outcome variables and measures

The outcomes were depression, anxiety, and positive and negative moods using the Self-Rating Depression Scale (SDS), Self-Rating Anxiety Scale (SAS), Hamilton Anxiety Scale, Hamilton Depression Scale, and the Positive and Negative Affect Scale (PANAS).

2.5.1 | Demographic and clinical data

Baseline demographic or clinical data include the GAD patients' gender, age, marital status, education level, mode of health insurance, and presence of family history.

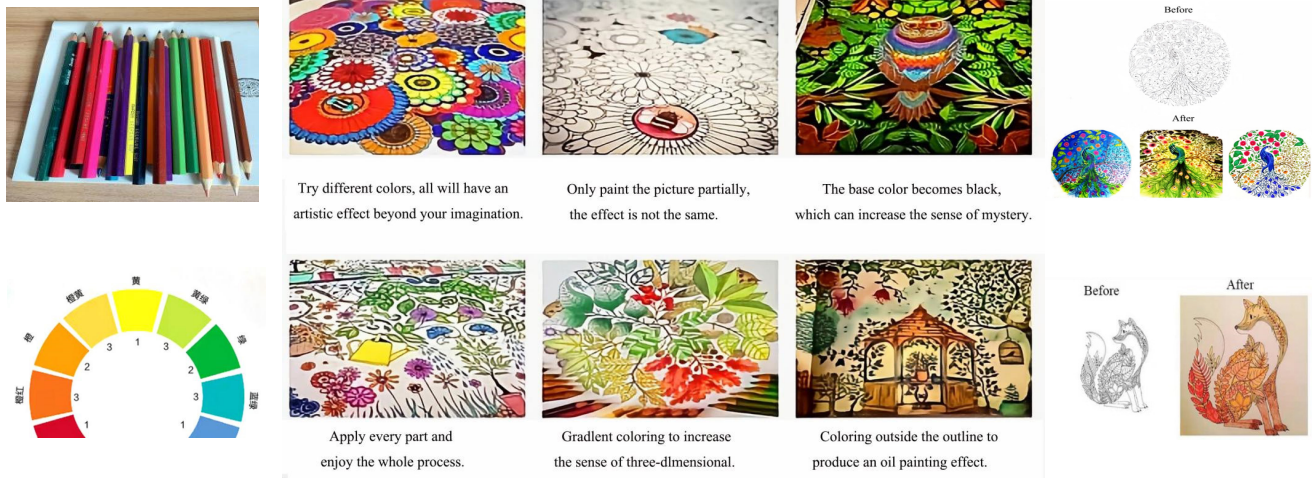
1 Prepare the colored pencils;**2 Relax and feel free to choose where to start coloring to fully unleash your magic;****3 Use each color wisely and let them release different energy;**

FIGURE 1 Program content of coloring therapy

2.5.2 | Assessment of anxiety levels

HAMA and SAS were used to assess the anxiety level. HAMA rates the severity of anxiety symptoms, which includes two subscales of mental anxiety and somatic anxiety with 14 entries, using a Likert 5-point scale with scores ranging from 0 to 90.¹² The higher the score, the more severe the anxiety symptoms, where a score of ≥ 14 is considered the definite anxiety state. SAS assesses patients' subjective feelings of anxiety. SAS consists of 15 items on a positive scale and 5 items on a negative scale, using a Likert 5-point scale, and is classified according to the score as mild anxiety 50–59 points, moderate anxiety 60–69 points, and severe anxiety 70 points or more.^{13,14}

2.5.3 | Assessment of depression levels

HAMD and SDS were used to assess the level of depression. HAMD rates the severity of depressive symptoms, and the 24-item version was selected for this study using a Likert 5-point scale, with scores ranging from 0 to 86; the higher HAMD scores indicate the more severe depressive mood,¹⁵ which is now widely used. SDS accurately reflects the subjective level of depression felt by the self-assessor. The scale comprises 20 entries, including 10 positive and 10 negative entries, and is rated on a 5-point Likert scale, with scores classified as 53–62 for mild depression, 63–72 for moderate depression, and 73 or more for major depression.¹⁶

2.5.4 | Assessment of positive and negative emotional levels

PANAS comprises two dimensions of positive and negative emotions, with 10 items each, using the Likert 5-point scale. The scores

of both dimensions are 0–40, with higher positive mood scale scores indicating higher positive emotions, higher negative mood scores indicating stronger negative emotions, and Cronbach's alpha coefficient of .88 and .85, respectively, with good reliability.^{17,18}

2.6 | Statistical analysis

In this study, SPSS24.0 software was used for the statistical analysis of data; the mean and standard deviation ($M \pm SD$) were used for measurement data conforming to normal distribution; frequency (percentage) was used for count data. Two-sample t-test (between-group comparison) was used for the comparison of two-sample data in randomized design; paired t-test (within-group comparison) was used for the comparison of paired data; and two-test was used for count data. All analyses were tested with a significance level of $p < .05$.

3 | RESULTS

3.1 | Participants' flow through the trial

In this study, 48 patients comprised the experimental group and 48 patients the control group. Five patients (10%) in the experimental group dropped out halfway (two patients were transferred to another hospital for treatment, two patients requested for early discharge, and one patient was too busy to participate), and three patients (6.2%) in the control group withdrew due to early discharge. The total dropout rate was 8.3% (8/96), as shown in Figure 2.

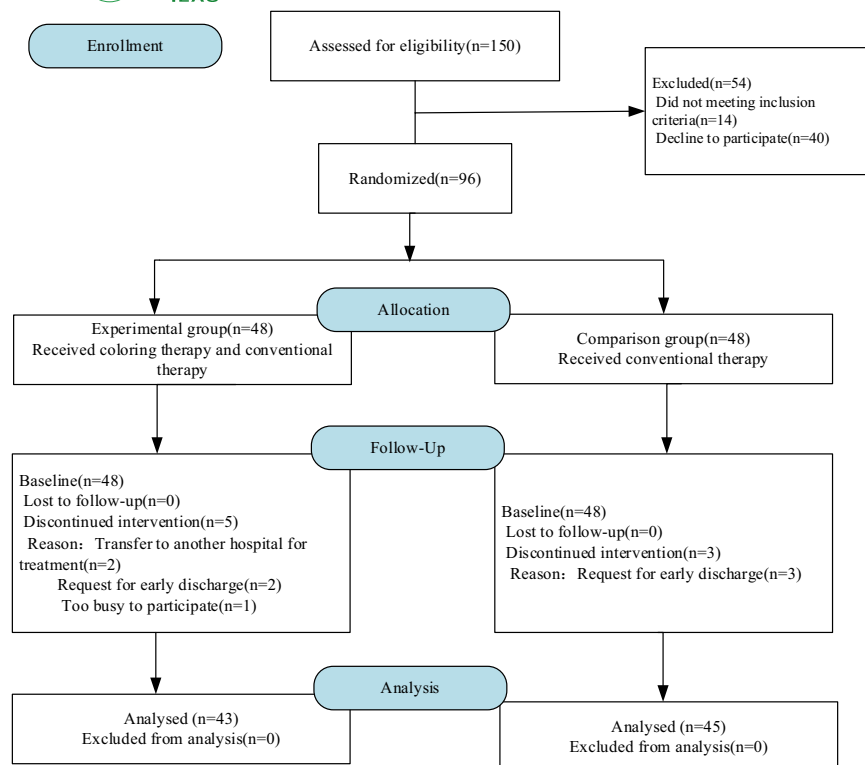


FIGURE 2 Flow chart of the study participants

3.2 | Participant characteristics

The demographic and clinical data of the patients in the two groups are presented in Table 1. There was no significant difference between the two groups ($p > .05$).

3.3 | Effects of coloring treatment on the anxiety level of GAD patients

Before the intervention, the overall mean of the HAMA/SAS scores in the experimental group was not significantly different from that of the HAMA/SAS scores in the control group (HAMA: $t = 0.73$, $p = .470$; SAS: $t = 0.67$, $p = .500$). After the intervention, there were statistical differences between the experimental group and the control group in the HAMA/SAS scores between and within the group ($p < .001$). The minus between the experimental group pre- and postintervention and that between the control group pre- and postintervention were statistically different (HAMA: $d = 1.45$, 95% CI [confidence interval] (1.48, 7.91), $p = .011$; SAS: $d = 3.87$, 95% CI (1.73, 6.00), $p = .001$), as presented in Tables 2 and 5.

3.4 | Effects of coloring treatment on the depressed level of GAD patients

Before the intervention, the overall mean of the HAMD/SDS scores in the experimental group was not significantly different from that of the HAMD/SDS scores in the control group (HAMD: $t = 0.40$, $p = .693$;

SDS: $t = 0.81$, $p = .419$). After the intervention, there were statistical differences between the experimental group and the control group in the HAMD/SDS scores between and within the group ($p < .001$). The minus between the experimental group pre- and postintervention and that between the control group pre- and postintervention were not statistically different (HAMA: $d = 0.59$, 95% CI (-0.68, 1.85), $p = .358$; SDS: $d = 1.40$, 95% CI (-0.74, 3.53), $p = .197$), as presented in Tables 3 and 5.

3.5 | Effects of coloring treatment on positive and negative emotions of GAD patients

Before the intervention, the overall mean of the positive/negative emotions scale scores in the experimental group was not significantly different from that of the positive/negative emotions scale scores in the control group (positive: $t = 1.25$, $p = .213$; negative: $t = 0.49$, $p = .627$). After the intervention, there were statistical differences between the experimental group and the control group in the positive/negative emotions scale scores between and within the group ($p < .001$). The minus of positive emotions scale scores between the experimental group pre- and postintervention and that between the control group pre- and postintervention were statistically different ($d = 1.77$, 95% CI [0.14, 3.39], $p = .034$). The minus of negative emotions scale scores between the experimental group pre- and postintervention and that between the control group pre- and postintervention were not statistically different ($d = 1.42$, 95% CI [-0.27, 3.11], $p = .098$), as presented in Tables 4 and 5.

TABLE 1 Demographic and clinical data

Variable	Experimental group (n = 43)	Control group (n = 45)	t/ χ^2	p
Gender				
Male (%)	14 (32.6)	15 (33.3)	0.01 ^a	.938
Female (%)	29 (67.4)	30 (66.7)		
Age (mean \pm SD)	46.56 \pm 13.02	49.91 \pm 11.11	1.30 ^b	.197
Education				
Primary school (%)	22 (51.2)	19 (42.2)	1.91 ^a	.385
Middle/high school (%)	14 (32.6)	21 (46.7)		
Above high school (%)	7 (16.3)	5 (11.1)		
Marital status				
Unmarried (%)	4 (9.3)	3 (6.7)	1.41 ^a	.497
Married (%)	36 (83.7)	41 (91.1)		
Divorce (%)	3 (7.0)	1 (2.2)		
Profession				
1 (No fixed occupation) (%)	28 (65.1)	24 (53.3)	1.87 ^a	.616
2 (Workers) (%)	6 (14.0)	6 (13.3)		
3 (Technicians) (%)	6 (14.0)	9 (20.0)		
4 (Individual) (%)	3 (7.0)	6 (13.3)		
Medical insurance type				
Medical insurance (%)	22 (51.2)	23 (51.1)	1.30 ^a	.550
Agricultural insurance (%)	14 (32.6)	18 (40.0)		
Own expense (%)	7 (16.3)	4 (8.9)		
Family history				
Negative (%)	40 (93.0)	41 (91.1)	0.00 ^a	>.999
Positive (%)	3 (7.0)	4 (8.0)		

Abbreviation: SD, standard deviation.

^a χ^2 .

^bt.

TABLE 2 Comparison of anxiety levels between the GAD patients in the experiment and control groups

Variable	Group	Before	After	t	p
		Mean \pm SD	Mean \pm SD		
HAMA	Experiment (n = 43)	17.74 \pm 2.47	3.58 \pm 1.58	33.04 ^a	<.001
	Control (n = 45)	17.36 \pm 2.55	4.64 \pm 1.87	34.99 ^a	<.001
	t	0.73 ^b	2.87 ^b		
	P	0.470	0.005		
SAS	Experiment (n = 43)	56.30 \pm 4.31	36.84 \pm 4.11	26.47 ^a	<.001
	Control (n = 45)	55.71 \pm 3.88	40.11 \pm 4.43	19.97 ^a	<.001
	T	0.67 ^b	3.59 ^b		
	P	0.500	0.001		

Abbreviations: HAMA, Hamilton Anxiety Scale; SAS, Self-Rating Anxiety Scale.

^aPaired t-test.

^bIndependent samples t-test.

4 | DISCUSSION

4.1 | The effectiveness of coloring therapy

Coloring therapy belongs to the category of art therapy and is an activity that creates a positive state of mind,¹⁹ which not only can help

participants focus their attention and devote themselves to the present moment but also can alleviate anxiety states. Also, it can enable participants to express negative emotions through free coloring on existing images. Compared to other art therapies, coloring therapy does not have complex requirements for participants and does not require any training or skill, so more patients could receive coloring therapy in

Variable	Group	Before	After	t	p
		Mean ± SD	Mean ± SD		
HAMD	Experiment (n = 43)	14.44 ± 3.30	3.23 ± 1.13	23.67 ^a	<.001
	Control (n = 45)	14.71 ± 3.07	4.09 ± 1.77	24.96 ^a	<.001
	t	0.40 ^b	2.72 ^b		
	p	.693	.008		
SDS	Experiment (n = 43)	51.14 ± 3.80	36.74 ± 3.71	22.58 ^a	<.001
	Control (n = 45)	51.96 ± 5.51	38.96 ± 4.43	15.22 ^a	<.001
	t	0.81 ^b	2.53 ^b		
	p	.419	.013		

Abbreviations: HAMD, Hamilton Depression Scale; SD, standard deviation; SDS, Self-Rating Depression Scale.

^aPaired t-test.

^bIndependent samples t-test.

TABLE 3 Comparison of depression levels between the GAD patients in the experiment and control groups

Variable	Group	Before	After	t	p
		Mean ± SD	Mean ± SD		
Positive	Experiment (n = 43)	24.35 ± 4.05	37.40 ± 2.73	24.51 ^a	<.001
	Control (n = 45)	23.07 ± 5.41	34.16 ± 4.11	14.70 ^a	<.001
	t	1.25 ^b	4.34 ^b		
	p	.213	<.001		
Negative	Experiment (n = 43)	32.28 ± 4.68	20.81 ± 2.58	18.65 ^a	<.001
	Control (n = 45)	32.78 ± 4.91	22.73 ± 2.38	17.12 ^a	<.001
	t	0.49 ^b	3.64 ^b		
	p	0.627	<.001		

Abbreviation: SD, standard deviation.

^aPaired t-test.

^bIndependent samples t-test.

TABLE 4 Comparison of positive and negative emotions between the GAD patients in the experiment and control groups

Variable	Group	Mean ± SD	95% CI for mean difference	t	p
HAMA	Experiment (n = 43)	14.16 ± 2.81	1.45 (0.34, 2.57)	2.59	.011
	Control (n = 45)	12.71 ± 2.44			
HAMD	Experiment (n = 43)	11.21 ± 3.11	0.59 (-0.68, 1.85)	0.92	.358
	Control (n = 45)	10.62 ± 2.86			
SAS	Experiment (n = 43)	19.47 ± 4.82	3.87 (1.73, 6.00)	3.60	.001
	Control (n = 45)	15.60 ± 5.24			
SDS	Experiment (n = 43)	14.40 ± 4.18	1.40 (-0.74, 3.53)	1.30	.197
	Control (n = 45)	13.00 ± 5.73			
Positive	Experiment (n = 43)	13.05 ± 3.49	1.76 (0.17, 3.34)	2.21	.030
	Control (n = 45)	11.29 ± 3.95			
Negative	Experiment (n = 43)	11.47 ± 4.03	1.42 (-0.27, 3.11)	1.67	.098
	Control (n = 45)	10.04 ± 3.94			

Abbreviations: HAMA, Hamilton Anxiety Scale; HAMD, Hamilton Depression Scale; SAS, Self-Rating Anxiety Scale; SD, standard deviation; SDS, Self-Rating Depression Scale.

TABLE 5 Comparison of the minus between pre- and post intervention of each outcome index

general.²⁰ In this study, 45 GAD patients in the control group received conventional medication and physical therapy, and 43 GAD patients in the experimental group received coloring therapy and the therapy given to the control groups. The results of the study showed that after 3 weeks of intervention, anxiety, depression, and positive and negative emotions in both the experimental and control groups improved compared with those before intervention ($p < .05$), and the anxiety and positive emotions in the experimental group were statistically different from those in the control group ($p < .05$), and the improvement in anxiety and positive emotions in the experimental group was significantly better than that in the control group ($p < .05$). Analyzing the results of this study in conjunction with previous studies,²¹⁻²³ abnormalities in thinking, consciousness, cognition, and neurostimulation were found in patients with GAD. Therefore, this study will analyze the effects of coloring treatment on anxiety, depression, and positive and negative emotions in patients with GAD from both psychological and physiological perspectives to provide new ideas for the subsequent treatment of GAD.

4.2 | Coloring therapy can relieve anxiety symptoms in GAD patients

The results of this study suggest that coloring therapy combined with conventional medication and physical therapy can reduce the current mental and somatic anxiety of patients with GAD and effectively reduce the level of self-perceived anxiety. The effect of adding coloring therapy to conventional treatment was more significant in reducing anxiety levels. Similar to the results of existing studies, Kaimal et al.²⁴ implemented a 45-min-long coloring session in a unique studio for 25 healthcare workers and 9 caregivers of cancer patients in an oncology unit and showed a significant decrease in the anxiety levels of healthcare workers and caregivers compared to the pre-intervention period. In addition, when coloring therapy was administered to college students with anxiety disorders,^{11,25} community-dwelling elderly,²⁶ patients attending the emergency department,²³ women in late pregnancy,²⁷ and cancer patients,^{28,29} the results showed some reduction in anxiety in this population compared to the pre-intervention period. This study used GAD patients as subjects to confirm the anxiety-relieving effect of coloring therapy and to broaden the scope of diseases treated with coloring therapy. There are abnormalities in emotion regulation and inhibition in patients with anxiety disorders. Izhar et al.³⁰ conducted a 6-week breathing mindfulness intervention on 20 neurotic female college students and then observed their electroencephalogram (EEG) in resting and mindful states. It was found that mindfulness intervention can modulate neuroticism and cognitive biases to a large extent, and alpha, theta, and beta waves in brainwaves are closely related to mindfulness activities. In the resting state, α and θ increase, indicating that mindfulness intervention can improve the anxiety state of neurotic students. The coloring treatment used in this study is considered to mimic a positive mindfulness intervention¹⁰ and reduces anxiety levels in GAD patients by a mechanism similar to theirs, with the potential to reduce the beta

and gamma waves of the EEG as well as increase the alpha and theta waves, shifting the patient from a state of heightened alertness to physical and mental relaxation. Campenni and Hartman³¹ found that patients with anxiety disorders lack a sense of security, and the complete graphic outline of the mandala can be considered as a protective space that provides patients with an adequate sense of security during coloring therapy, which in turn reduces their anxiety levels. Similarly, the implemented coloring treatment also involves coloring activities in contoured shapes. The immersion in coloring activities enables GAD patients to gain sufficient psychological security and ultimately achieves a good effect of reducing anxiety.

4.3 | Coloring therapy can relieve depression symptoms in GAD patients

The results of this study illustrate the difference between the coloring treatment combined with conventional treatment group and the conventional treatment group in reducing depression in GAD patients. This not only broadens the scope of diseases treated by coloring but also confirms the effect of coloring therapy on improving depression in patients, similar to the study by Bosman et al.²⁹ However, the existing studies on the mechanism of action of coloring treatment to alleviate depressive symptoms in GAD patients are unclear. It has been proposed³² that dysfunctional reinforcement learning processes and dysregulated reward circuits may partially underlie the pathology of depressive symptoms, mainly manifested by a lack of pleasure or hypersensitivity to reward, with key neural regions, including the lateral rein nucleus, ventral tegmental area, and substantia nigra, and that the severity of pleasure deficit modulates the relationship between reward expectancy and reward prediction error signals in the ventral striatum; specifically, the presence of individuals with severe pleasure deficit symptoms may have deficits in aspects related to reward learning, and patients with low reward sensitivity better understand reward prediction error signals in reward tasks; therefore, patients with depressive symptoms require more refined and targeted psychotherapeutic interventions. In our study, patients with GAD used their preferred colors and patterns for coloring creations, which not only provided a certain amount of pleasure in the short repetitive actions but also expressed stressful events related to the disease through their chosen colors, patterns, and coloring trajectories, which in turn assisted the psychotherapist in providing targeted psychotherapeutic solutions, ultimately achieving the effect of reducing depression.

In addition to mood disorders, depressed patients are found to have cognitive impairment, which is attributed to the abnormal reduction in the left dorsolateral prefrontal function involved in the regulation of positive emotions in depressed patients.³³ However, Silvia's³⁴ study found that coloring activities, in which participants integrated existing patterns and colors into new works of art, improved their creative thinking and cognitive abilities, and Daudén Roquet and Sas's³⁵ study also showed that coloring therapy engages patients fully in coloring activities, which

can improve colorists' insight and revisit these negative emotional experiences, ultimately achieving a reduction in depressed mood. Thus, although GAD patients had cognitive and affective impairments, participants were able to fully engage in coloring activities for simple creation, clarify and expand their thoughts, and improve their perception of negative emotions, thus reducing their negative emotions.

4.4 | Coloring therapy can increase positive mood and decrease negative mood in GAD patients

The results of this study indicate that coloring treatment can improve positive emotions and reduce negative emotions in GAD patients and that coloring treatment combined with conventional treatment is more effective than conventional treatment in improving positive emotions. Similar to Zhang's³⁶ study, deep brain stimulation of the brain's reward system reduced depression and prompted positive motivation to seek pleasure and reward stimulating events. In the present study, noninvasive and long-duration coloring activities were given to GAD patients, with the possibility of bringing the brain to deep stimulation, therefore decreasing negative emotions and increasing positive emotions in GAD patients. However, it has also been found³⁷ that electrical stimulation near the ventral medial part of the hypothalamus has a causal relationship with human emotional experience and that stimulation at different sites in the amygdala, hippocampus, ventral medial-prefrontal and orbitofrontal cortices, anterior cingulate, ventral anterior insula, orbitofrontal cortex, and dorsal posterior insula will have different emotional experiences such that the stimulation of insula and amygdala will increase negative emotions and stimulation of dorsal anterior cingulate will increase positive emotions, which may affect the analysis of the effect of coloring treatment in reducing negative emotions because the present study did not further understand the sites of deep brain stimulation and take relevant beneficial measures for coloring treatment.

For the enhancement of positive mood, it has been found^{38,39} that oxytocin is a key mechanism for social relationship buffering; social contact stimulates increased release of oxytocin from the paraventricular nucleus of the hypothalamus, which inhibits the hypothalamic-pituitary-adrenal axis to assist in the regulation of personal mood; and good interpersonal trusting relationships are considered positive social contact, which has a good effect in enhancing positive mood. Together with the fact that self-concept clarity is an important indicator in positive emotion that increases the amplitude of low-frequency fluctuation fractions in the right precentral gyrus and decreases the connectivity performance of the resting state in the right precentral and left inferior parietal lobes, increasing self-concept clarity also implies an increase in positive emotion.⁴⁰ Reviewing the coloring process in this study, on the one hand, the long duration and high frequency of the coloring activities in this study (duration of 3 weeks, frequency of 30–120 min five times a week) enabled professional psychotherapists and patients

to establish a high level of interpersonal trust, and the harmonious doctor-patient relationship made patients more willing to actively share their current mental activities and related emotional problems, which in turn improved positive emotions. On the other hand, participants immersed in coloring activities can present their unconscious negative emotions and gradually repair and integrate their inner emotions to find a clear self-concept that facilitates positive emotional support. Therefore, coloring treatment was more effective than conventional treatment in improving positive emotions in GAD patients.

5 | SUMMARY

The results of this study showed that coloring therapy combined with conventional therapy in GAD patients could better alleviate anxiety-depression symptoms, enhance positive moods, and reduce negative moods, further enhancing the therapeutic effects of GAD patients. On the one hand, coloring therapy can directly affect patients' psychological state and physiological parameters, and on the other hand, it facilitates patients' nonverbal self-expression and promotes self-actualization. In conclusion, coloring therapy is easy, safe, practical, efficient, synergistic, and is suitable for patients with GAD.

However, there are still some limitations in this study. First, the neural and muscle electrical activity of GAD patients was not monitored due to the limitations of the conditions. Second, the colors and patterns preferred by GAD patients during coloring therapy were not observed as well as the related influencing factors were analyzed. Existing studies^{40,41} found that different colors and patterns have different stimulating effects on the nervous system of GAD patients. Therefore, we believe that coloring therapy can relieve patients' anxiety and depressive symptoms as well as change positive and negative moods related to the colors and patterns chosen by GAD patients when coloring. Therefore, to further study and verify the stimulating effect of different colors on different parts of the brain and to clarify the mechanism of coloring therapy and the advantages of coloring therapy for GAD patients, we will conduct in-depth related research in two aspects. On the one hand, to ensure the scientific validity of coloring therapy, we will explore the optimal timing, modality, and methods of coloring therapy. On the other hand, to promote the application of coloring therapy, we will explore the effectiveness of coloring therapy in improving the quality of life and recurrence rate of GAD patients to obtain the best economic benefits of coloring therapy.

AUTHOR CONTRIBUTIONS

Bosomtwe Samuel and Hongmei Wang designed and analyzed the experiment and drafted the manuscript. Chengdong Shi and Yongliang Pan were involved in the design of the experiment. Weiyu Zhu and Zhou Jing assisted with the experiment and analysis of the data. Yuzi Yu conducted data analysis and prepared the tables. Yongliang Pan revised key sections of the article and approved the

final version for publication. All the authors reviewed, discussed, and approved the final manuscript.

ACKNOWLEDGMENTS

We are grateful to the National Natural Science Foundation of China (grant number 31672295).

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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How to cite this article: Samuel B, Wang H, Shi C, et al. The effects of coloring therapy on patients with generalized anxiety disorder. *Anim Models Exp Med.* 2022;5:502-512. doi: [10.1002/ame2.12256](https://doi.org/10.1002/ame2.12256)