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Differentiated Regulatory Mechanisms of Art Therapy on Brain Health

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Abstract. Currently, suboptimal mental health, emotional disorders and traumatic stress disorders are rising year by year, while traditional psychological interventions suffer from homogenization and insufficient targeting. Based on neuroplasticity and the Expressive Therapies Continuum theory, this study systematically analyzes pathological characteristics and repair logic of core brain regions including the prefrontal cortex, amygdala and hippocampus, and compares differentiated neural regulatory effects of four categories of art forms: painting, music, handcraft and passive aesthetic appreciation. The study identifies brain region activation rules and intervention advantages corresponding to each art modality, and distinguishes the varied functions of active creation and passive aesthetic appreciation in emotion regulation, cognitive remodeling and traumatic memory repair. This study makes up for the deficiency that existing research stresses practical effects yet lacks analysis of differentiated action mechanisms. It establishes an intervention framework matching art forms, cerebral regulatory characteristics and crowd demands, and promotes art therapy from experience-based implementation toward more targeted scientific intervention. Future research can adopt multimodal neuroimaging experiments to further quantify intervention thresholds of different art modalities and long-term cerebral functional remodeling rules, so as to improve the precise art therapy system.

Keywords: Art therapy, neuroscience, neuroplasticity, biological psychology

1. Introduction

Nowadays, psychological pressure has become normalized. Mental problems such as anxiety, depression and traumatic stress are increasing year by year. More than one billion people worldwide are suffering from various mental health disorders [1], and the demand for physical and mental maintenance as well as rehabilitation intervention among the public is growing urgent. Traditional verbal psychological intervention has limited suitability for people with emotional disorders and traumatic dissociation, and suffers from homogenized intervention and poor targeting. As a non-invasive, experience-based auxiliary intervention method, art therapy relies on diverse forms including painting, handcraft, music and aesthetic appreciation to externalize emotions, regulate body and mind, and repair brain functions. It has been widely applied in mental health intervention, clinical rehabilitation and brain health maintenance. With the popularization of neuroimaging technologies such as fMRI and fNIRS, the neuroscientific mechanisms of art therapy have obtained

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abundant empirical support. Neuroplasticity and brain network remodeling have become the core basis for explaining its therapeutic effects.

Existing studies have confirmed that various forms of art therapy can specifically activate brain regions related to emotion, cognition and reward, effectively relieve negative emotions and repair traumatic memories. Some studies have preliminarily indicated that art therapy can remodel the operating patterns of key internal brain neural networks. Nevertheless, most relevant studies focus on practical application and subjective psychological outcomes. There lacks systematic sorting of the differentiated neural mechanisms of various art modalities for different recipient groups. Targeted regulatory rules of different therapeutic forms have not formed a complete system, which hinders the implementation of precise art intervention schemes.

On this basis, this study takes core theories including neuroplasticity and the Expressive Therapies Continuum theory as the foundation. It selects four mainstream art therapy forms and four common groups with abnormal brain health as research subjects. Combined with secondary neuroimaging data and small-scale verification experiments, this study systematically explores the specific regulatory mechanisms of different art modalities on core brain regions and brain networks, and sorts out differentiated neural action pathways and intervention adaptation logic. This study aims to construct a precise regulation model of "art modality – brain network – crowd demand", enrich the theoretical system of neural mechanisms of art therapy, provide scientifically feasible practical ideas for clinical psychological rehabilitation and daily public mental maintenance, and promote art therapy from experience-based practice toward targeted precise psychological intervention.

2. Theoretical basis of brain health related to art therapy

2.1. Neuroplasticity theory

Neuroplasticity refers to the brain's capacity for self-renewal, which enables continuous adjustment of brain functions through external experience. It serves as the core physiological foundation for the efficacy of art therapy. Its core principle lies in the lifelong dynamic adjustment and self-modification of brain structures. With positive external experiential stimulation, the brain can activate neural signal transmission, strengthen beneficial neural connections, weaken and eliminate useless negative neural pathways, renew neural cell states, and integrate the overall brain operating mode. It ameliorates brain imbalance from microstructures to overall functions, and re-optimizes the brain's capacity to regulate body, mind, emotion and state [2]. The brain relies on this mechanism to sustain stable emotion, cognition and memory. Long-term stress and psychological trauma disrupt cerebral balance, trigger mental disorders such as anxiety and depression, and gradually form solidified negative thinking and abnormal brain function states.

Art therapy delivers positive experiential stimulation to the brain and drives self-repair of cerebral functions to improve negative psychological states. Depending on neuroplasticity, diverse art forms can trigger differentiated neural regulation at sensory, emotional and cognitive levels, remodel distinct neural connections in the brain, thereby generating different regulatory effects and realizing individualized physical and mental rehabilitation.

2.2. Expressive therapies continuum (ETC) theory

Proposed by Kagin and Lusebrink in 1978, the ETC theory is a core theory for neuroscientific research on art therapy. It clarifies the correlation among artistic creation, psychological state and

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brain activity. Through multi-level sensory and cognitive input, artistic creation sequentially engages somatic perception, emotional processing, abstract symbolism and integrative brain networks. It synchronously regulates core brain regions including the amygdala, prefrontal cortex and hippocampus via top-down and bottom-up pathways, alters the strength of neural connections, and further transforms individuals' psychological states. It provides theoretical support for precise and differentiated art intervention. The theory establishes a four-level progressive therapeutic system covering somatic perception, emotional release, cognitive adjustment and body-mind integration to form a complete therapeutic pathway.

Among these levels, the sensory level breaks through psychological defense and relieves physical tension, suitable for people with emotional numbness and traumatic stress. The emotional level relieves negative emotions with diverse artistic elements and improves emotional suppression. The cognitive level sorts out chaotic thoughts and corrects negative thinking. The integrative level achieves unity of body and mind and remodels the brain's thinking mode. Different art forms such as painting, music, handcraft and static aesthetic appreciation correspond to each therapeutic level to realize targeted cerebral regulation. Based on the ETC theory, this study clarifies the intervention characteristics of various art forms and provides theoretical grounds for constructing a precise art therapy model.

2.3. Analysis of functions and pathological characteristics of core brain regions and brain networks

2.3.1. Prefrontal cortex: core brain region for cognitive control and emotional regulation

The prefrontal cortex is the core cerebral region governing thinking regulation and emotion management. It dominates emotional balance, attentional regulation and rational control, and can suppress excessive negative emotions and coordinate the brain to complete normal memory processing. fMRI imaging studies confirm that individuals with depression and trauma generally exhibit decreased activation of the prefrontal cortex during emotional regulation tasks. The inhibitory neural pathway connection between the prefrontal cortex and amygdala weakens, so rational regulatory signals cannot effectively descend to constrain the emotional center. This serves as the direct circuit basis for emotional dyscontrol [3]. Among people with anxiety, depression and trauma, prefrontal cortex activity generally declines and regulatory capacity weakens, easily triggering repetitive rumination, inattention and uncontrollable emotions. Functional decline of this brain region directly leads to rigid thinking and aggravated emotional exhaustion, constituting an important cerebral pathological basis for various emotional psychological disorders [4].

2.3.2. Amygdala: core brain region for negative emotion processing and stress response

The amygdala mainly perceives negative emotions, responds to stress and stores fear memories. Under normal conditions, it can be restrained by rational cerebral functions to maintain emotional stability. This brain region has bidirectional neural projection pathways with the prefrontal cortex. Long-term stress alters synaptic potential balance, weakens the descending inhibition of the prefrontal cortex on the amygdala. Overexcitation of the amygdala in turn suppresses cognitive functions of the prefrontal cortex and forms mutually amplifying pathological conditions [5]. Long-term stress and psychological trauma render the amygdala hypersensitive and persistently overactive. Individuals tend to interpret external information negatively and experience continuous tension and fear, accompanied by excessive worry, low mood, traumatic flashbacks and

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hypervigilance. Meanwhile, overactivation of the amygdala further impairs rational regulation capacity, forming a vicious cycle of emotion and thinking that causes recurrent and persistent psychological disorders.

2.3.3. Hippocampus: core brain region for memory integration and neuroplasticity

The hippocampus is mainly responsible for memory sorting, fading of emotional memories and cerebral state regulation. It acts as a key region for cerebral self-repair and remodeling. Stress hormones damage hippocampal synaptic plasticity and hinder sequential integration of traumatic memories. Neuroimaging studies show that individuals with trauma have hippocampal volume atrophy and impaired plasticity of memory control circuits. Traumatic memories can hardly be incorporated into normal autobiographical memory frameworks and repeatedly intrude into consciousness [6]. Stress and trauma severely impair hippocampal functions, resulting in memory confusion and difficulty fading traumatic memories. Individuals fall into repetitive recollection, mental sluggishness and difficulty recovering emotionally. Symptoms including memory solidification and psychological dissociation induced by trauma and depression are closely associated with hippocampal damage. Therefore, the hippocampus also acts as a key target for art therapy to realize cerebral repair and improve cognitive and traumatic states [7].

3. Impacts of art therapy types on specific brain regions

3.1. Visual painting therapy: differentiated regulation of emotional release and cognitive remodeling

Widely applied, painting therapy corresponds to the emotional perceptual and cognitive symbolic levels of the ETC, realizing progressive emotional release and cognitive adjustment. A review on neural mechanisms among trauma groups indicates that painting creation strengthens descending inhibitory regulation of the prefrontal cortex on the amygdala, improves functional connectivity of the prefrontal cortex-amygdala pathway and reduces overactivation of negative emotions. fNIRS observations also reveal that thematic painting tasks steadily raise blood oxygen signals in the prefrontal cortex, offering neural evidence for cognitive reconstruction [7]. Studies demonstrate that painting creation activates the prefrontal cortex, inhibits excessive excitation of the amygdala, and coordinates multi-brain-region operation via hand movements to break negative thinking circuits.

Free doodling realizes immediate emotional release and suits people with acute anxiety and emotional suppression. Thematic painting guides thought sorting and improves negative cognition, applicable to individuals with long-term depression and mental rumination. Long-term practice facilitates hippocampal repair, optimizes memory integration capacity and fades traumatic memories, with both instant soothing and long-term cerebral functional rehabilitation effects [8].

3.2. Music therapy: emotional rhythm regulation and brain network homeostasis remodeling

Relying on auditory rhythm stimulation, music therapy has a low intervention threshold. It directly activates the brain reward system, alleviates amygdala stress responses and calms anxiety. It requires little in-depth thinking participation and is more suitable for individuals with language expression disorders and emotional numbness. Systematic reviews and brain imaging evidence show that soothing music regulates the prefrontal cortex-hippocampus-amygdala circuit, reduces stress-related neural arousal and elevates dopamine-related activity in reward pathways. However, such regulation

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mainly targets emotional rhythm and hardly promotes hippocampus-dominated traumatic memory reconstruction [9].

Slow-tempo music soothes nerves, inhibits excessive amygdala activation and improves anxiety and insomnia. Rhythmic music alleviates cognitive retardation in the prefrontal cortex and relieves thinking sluggishness caused by depression. Long-term intervention stabilizes emotional rhythm, yet its effects on hippocampus-mediated cognitive remodeling are limited. It mainly regulates neural rhythm and maintains physical and mental stability [10].

3.3. Handcraft therapy: body-mind integration and neural homeostasis regulation

Corresponding to the somatosensory level of the ETC, handcraft therapy relies on fine hand movements to coordinate the prefrontal cortex and hippocampus and alleviate trauma-induced dissociation. Neuroscience research proposes that sustained tactile sensation and bilateral hand movements activate the sensorimotor cortex, promote coordination between the sensorimotor network and default mode network, and help dissociated individuals re-establish connections between somatic perception and autobiographical memory. Repetitive handcraft operation stabilizes amygdala emotional fluctuations and simultaneously activates reward pathways [11]. Compared with painting and music, it delivers stronger somatic engagement and sorts ineffable traumatic emotions through physical creation.

Fine handcraft creation relies on the hippocampus to reorganize fragmented traumatic memories and suits PTSD populations. Repetitive handcraft operation calms amygdala emotional fluctuations, applicable to people with emotional disorders. A sense of achievement brought by creation activates reward pathways, regulates functions of the prefrontal cortex and hippocampus, and reconstructs stable physical and mental states while repairing brain functions [12].

3.4. Passive aesthetic therapy: brain network homeostasis regulation

Centered on art appreciation, passive aesthetic therapy imposes low intervention load and suits individuals suffering from burnout and severe emotional disorders. Neuroimaging pilot studies show that quietly viewing artworks elevates regulatory activity of the prefrontal cortex, moderately lowers high arousal signals of the amygdala and reduces sympathetic nervous stress levels induced by chronic stress. Nevertheless, passive viewing lacks somatic and cognitive engagement from active creation and cannot sufficiently mobilize the hippocampus to complete traumatic memory integration [13]. Aesthetic experience mildly activates the prefrontal cortex, moderately inhibits hypersensitive responses of the amygdala, and relieves mental fatigue and emotional exhaustion caused by prolonged stress.

This method features high safety and is mostly adopted for daily maintenance and auxiliary rehabilitation. Yet its intervention intensity is insufficient. It can hardly accomplish in-depth emotional relief and cognitive transformation merely depending on the prefrontal cortex. It needs to be combined with active therapeutic approaches such as painting and handcraft to jointly regulate the amygdala and hippocampus and form a stepped intervention scheme.

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4. Targeted differentiated regulation of art therapy for populations with psychological and abnormal brain health conditions

4.1. Individuals with emotional disorders (anxiety, depression): limbic system inhibition and prefrontal cortex functional remodeling

Typical cerebral pathologies of people with anxiety and depression include overactive emotional centers, weakened rational cerebral regulatory capacity and repeated activation of negative thinking, accompanied by amplified negative emotions, cognitive rumination and impaired emotion regulation [14]. This population adapts to an intervention scheme dominated by painting therapy and supplemented by music and aesthetic appreciation.

Free doodling and color creation reduce activity levels of emotional centers, calm hyperactivity of the cerebral emotional system, rapidly release negative emotions, and relieve anxious agitation and depressive numbness. Structured thematic painting continuously activates the prefrontal cortex, remodels cognitive regulatory functions, corrects negative cognitive biases and reduces recurring negative thoughts. Matched with passive aesthetic appreciation, it sustains neural homeostasis and curbs emotional fluctuations. Long-term intervention repairs the coordination mode between cerebral rational and emotional systems, remodels emotional processing patterns, and achieves symptom relief and cerebral functional rehabilitation [15].

4.2. PTSD populations with trauma: memory integration and dissociation rehabilitation

The core cerebral damage of PTSD lies in impaired memory sorting function, disordered memory processing and disrupted coordination between body and mind. Manifestations include fragmented traumatic memories, flashbacks, psychological dissociation and emotional numbness. Suitable interventions are structured handcraft creation and figurative thematic painting.

Clay modeling and structured handcraft activate the memory integration function of the hippocampus, sort fragmented traumatic memories, transform uncontrollable traumatic experiences into tangible entities, and repair disconnection between body and mind as well as memory confusion [16]. Figurative thematic painting reconstructs trauma cognition, weakens fixed cerebral responses to traumatic memories, simultaneously activates the prefrontal cortex, and restores coordinated emotion-memory processing modes [17].

Interventions for PTSD need to avoid disordered intense emotional stimulation. Reliant on controllable and structured artistic creation, they restore the brain's capacity for self-adjustment and holistic coordination, weaken traumatic neural imprints, and realize body-mind integration and cerebral functional remodeling.

5. Conclusion

Psychological pressure prevails in modern society. Mental problems including anxiety, depression and trauma grow increasingly common. Traditional psychological intervention methods are unitary and difficult to conduct targeted regulation for diverse populations. Most existing studies on art therapy only focus on practical improvement effects, while systematic differentiation of cerebral regulatory disparities among various art approaches is insufficient, lacking detailed and precise intervention evidence.

Combined with the brain's self-repair characteristics and the multi-level art therapy theory, this study summarizes abnormal manifestations and repair rules of core brain regions related to emotion

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and memory. It compares distinct regulatory advantages of painting, music, handcraft and art appreciation, distinguishes applicable scenarios of active creation and passive appreciation, and sorts out adapted art intervention approaches for individuals with emotional distress and trauma.

This study clarifies suitable populations and physical and mental regulatory characteristics of different art forms, complements the deficiency that existing research emphasizes practice yet lacks mechanism analysis, and provides references for refined application of art therapy. Restricted to theoretical sorting and summary of available data, this study lacks evidence from long-term large-scale experiments. Subsequent research can combine cerebral detection technologies to further define applicable scopes and intervention effects of various art therapies and improve the personalized art therapy system.

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