Personalized Pathways for Artificial Intelligence-Powered Receptive Music Therapy Based on the "Three Categories of Etiological Factors System" Principle

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Abstract. This study explores the theoretical framework for constructing personalized pathways in receptive music therapy by integrating the Traditional Chinese Medicine (TCM) principle of "Three Categories of Etiological Factors System" with artificial intelligence (AI) technology. The three dimensions—temporal appropriateness, geographical appropriateness, and individual appropriateness - offers a holistic approach to personalized healthcare that aligns with modern precision medicine. Through systematic analysis of how these three dimensions apply to music therapy practice, we propose a comprehensive AI-based multidimensional assessment model and dynamic adjustment mechanism. The research establishes a theoretical system encompassing three core modules: individual characteristic identification, environmental factor analysis, and temporal pattern recognition. This framework enables the intelligent selection and dynamic optimization of therapeutic music based on patients' physiological states, psychological profiles, cultural backgrounds, circadian rhythms, seasonal variations, and environmental contexts. By leveraging machine learning algorithms and deep learning technologies, the system can process multimodal data to generate highly personalized treatment protocols and adjust them in real-time according to therapeutic responses. This integration of ancient medical wisdom with cutting-edge AI technology provides novel theoretical perspectives and practical pathways for achieving precision-oriented and intelligentized music therapy, potentially enhancing treatment efficacy and accessibility across diverse clinical settings including mental health, neurological rehabilitation, pain management, and pediatric developmental disorders.

Keywords: Music Therapy; Artificial Intelligence; Personalized Medicine; Traditional Chinese Medicine Theory; Treatment Pathways.

1. Introduction

Music therapy, as a non-pharmacological intervention, has demonstrated unique therapeutic value in mental health, rehabilitation medicine, and special education. Receptive Music Therapy, as one of the important forms of music therapy, achieves therapeutic purposes through carefully selected music listening experiences. In this process, soothing string quartets can help alleviate anxiety, rhythmically vibrant piano pieces can stimulate positive emotions and improve depressive states, while classical music with steady beats can enhance concentration and mental clarity. However, traditional receptive music therapy often adopts standardized treatment protocols that fail to fully consider individual differences and environmental factors, thereby limiting improvements in therapeutic effectiveness.

In recent years, rapid developments in Artificial Intelligence(AI) technology [1] have brought revolutionary changes to the healthcare field. AI technology applications provide intelligent support tools for music therapy. However, technology is merely a means; more importantly, it is about deeply integrating traditional medical wisdom with modern therapeutic concepts to construct a truly patient-centered music therapy system.

The Traditional Chinese Medicine(TCM) principle of "Three Categories of Etiological Factors System" emphasizes that treatment should adopt corresponding strategies [2] based on differences in time, geography, and individuals, which highly aligns with the core concepts of modern precision medicine. "Treatment according to temporal factors" in music therapy not only focuses on circadian rhythms but more deeply reflects accommodation to patients' emotional cycles and disease development stages, such as selecting gentle and stable music accompaniment in the morning for depression characterized by morning severity and evening relief, gradually increasing music's vitality and color in the afternoon, and promoting sleep with peaceful and soothing melodies at night. "Treatment according to geographical factors" considers not only the physical environment but emphasizes the influence of cultural geography on music perception—patients in southern regions may resonate more with soft and graceful Jiangnan silk and bamboo music, while northern patients may respond better to bold and majestic ethnic orchestral music. "Treatment according to individual factors" deeply considers individuals' musical memories, emotional experiences, and personality traits—introverted individuals are suited to simple and refined chamber music, while extroverted personalities may have better therapeutic responses to rich and colorful symphonic music. This deep integration enables receptive music therapy [3] to truly achieve "one prescription per person," "one method per time," and "one strategy per location" personalized treatment.

Current challenges in personalized music therapy research include: First, lack of systematic theoretical frameworks to guide personalized treatment pathway design; Second, incomplete multidimensional assessment systems for individual differences; Third, mechanisms for dynamic monitoring and protocol adjustment of therapeutic effects need optimization; Fourth, unclear mechanisms of cultural background and environmental factors in treatment.

This study aims to construct a theoretical framework for AI-Powered personalized pathways in receptive music therapy guided by the "Three Categories of Etiological Factors System" principle. By integrating TCM wisdom with modern AI technology, we explore how to achieve precision and intelligence in music therapy. The innovation of this research lies in: systematically applying the "Three Categories of Etiological Factors System" principle to the music therapy field for the first time, constructing a multidimensional, dynamic personalized treatment theoretical model; proposing an intelligent assessment and decision support system architecture based on AI technology; and providing new ideas and methods for theoretical development and practical application of music therapy.

2. Materials and Methods

2.1 Theoretical Analysis Methods

This study employs a combination of theoretical construction and model derivation methods, constructing an AI-Powered personalized music therapy theoretical framework through literature analysis, concept mapping, and logical reasoning.

First, using literature review methodology, we systematically examine the core connotations of the "Three Categories of Etiological Factors System" principle and its applications in modern medicine. Through in-depth analysis of classical TCM texts and modern research literature, we extract key elements of the three dimensions—temporal, geographical, and individual factors—in health interventions.

Second, employing interdisciplinary theoretical integration methods, we organically fuse theoretical achievements from music therapy, artificial intelligence, and systems medicine. Through concept mapping techniques, we establish corresponding relationships between the "Three Categories of Etiological Factors System" principle and music therapy elements, clarifying specific manifestations of each dimension in music therapy.

2.2 Model Construction Methods

In theoretical framework construction, we employ hierarchical analysis and system modeling methods. The personalized music therapy pathway is decomposed into three core modules: individual characteristic recognition module, environmental adaptation module, and temporal optimization module. Each module is further subdivided into several subsystems, forming a hierarchical theoretical architecture.

The individual characteristic recognition module is constructed based on the bio-psycho-social medical model, integrating multidimensional information including physiological indicators, psychological characteristics, and sociocultural backgrounds. Through theoretical derivation, we determine the mechanisms of AI technology in collection, analysis, and integration of various dimensional information. The environmental adaptation module design considers three levels: physical environment, social environment, and cultural environment. By analyzing the influence mechanisms of environmental factors on music perception and therapeutic effects, we construct an environment-music-individual interaction model. The temporal optimization module, based on chronobiology and music therapy cycle theory, explores the theoretical basis for treatment timing selection, course design, and dynamic adjustment.

2.3 AI Technology Application Framework Design

At the AI technology application level, we employ technology roadmap methodology to design the functional architecture of an intelligent music therapy system. This includes four layers: data collection layer, feature extraction layer, decision support layer, and effect evaluation layer.

The data collection layer encompasses multi-source data acquisition methods including physiological signal monitoring, psychological assessment scales, and environmental parameter recording. The feature extraction layer employs machine learning algorithms to [4] extract key treatment-related features from massive data. The decision support layer, based on deep learning and knowledge graph technologies, realizes intelligent treatment protocol recommendations. The effect evaluation layer establishes a multidimensional evaluation index system to achieve quantitative assessment of therapeutic effects.

3. Results and Discussion

3.1 Mapping Relationships Between "Three Categories of Etiological Factors System" Principle and Music Therapy

The research establishes systematic mapping relationships between the "Three Categories of Etiological Factors System" principle and music therapy elements. "Treatment according to individual factors" corresponds to individuals' physiological characteristics, psychological states, music preferences, and cultural backgrounds; "Treatment according to temporal factors" is reflected in treatment timing selection, therapy cycle design, and rhythm synchronization adjustment; "Treatment according to geographical factors" encompasses treatment environment settings, regional cultural characteristics, and social support systems.

Establishing these mapping relationships provides systematic theoretical guidance for personalized music therapy design. Compared to traditional single-dimension personalized protocols, the three-dimensional integration method more comprehensively considers various factors affecting therapeutic effectiveness. For example, when designing music therapy protocols for anxiety disorder patients, we must consider not only the patient's anxiety level and music preferences (individual factors), such as selecting soothing Baroque music or nature soundscapes to relieve tension, but also choose appropriate treatment times according to their circadian rhythms (temporal factors), such as using progressive relaxation music [5] when anxiety intensifies in the evening, and consider the noise level and privacy of their environment (geographical factors), as treatment is more effective in quiet, private spaces.

3.2 AI-Powered Multidimensional Assessment Model

The research proposes an AI technology-based multidimensional assessment model comprising three core assessment dimensions and nine sub-dimensions. The individual dimension includes physiological state assessment, psychological characteristic analysis, and social function evaluation; the temporal dimension encompasses circadian rhythm assessment, seasonal adaptation analysis, and therapy cycle optimization; the environmental dimension contains physical environment assessment, social environment analysis, and cultural environment recognition.

AI technology plays a crucial role in the assessment model. Machine learning algorithms can learn complex relationships between individual characteristics and treatment responses from large amounts of historical data, achieving precise individual profiling. Deep learning technology can identify subtle patterns in physiological signals and predict optimal treatment timing. Natural language processing technology can analyze patients' verbal expressions to assess their psychological states and cultural backgrounds.

Compared to traditional scale assessment methods, the AI-Powered assessment model has the following advantages: First, it can process multimodal data to achieve more comprehensive assessment; Second, it can discover hidden feature correlations to improve assessment accuracy; Third, it supports real-time dynamic assessment to promptly capture state changes; Fourth, it reduces subjective bias and improves assessment objectivity.

3.3 Personalized Pathway Generation Mechanism

Based on the "Three Categories of Etiological Factors System" principle and AI technology, the research constructs a personalized music therapy pathway generation mechanism. This mechanism includes four stages: initial assessment, protocol generation, dynamic adjustment, and effect feedback, forming a closed-loop optimization system.

In the initial assessment stage, the system comprehensively collects information from three dimensions—individual, temporal, and environmental—to construct multidimensional feature vectors. In receptive music therapy, this includes assessing patients' emotional states, music response patterns, and environmental adaptability. In the protocol generation stage, protocol generation follows the core principles of "Three Categories of Etiological Factors System." Individual-appropriate protocol design deeply understands each person's unique musical language, like TCM pulse-taking that sensitively perceives individuals' musical pulses, providing peaceful and balanced music for those with gentle temperaments and selecting vibrant and powerful melodies for those with passionate temperaments. Temporally-appropriate protocol arrangements are like following natural timing, awakening body and mind with fresh and lively music in the morning, maintaining states with stable and expansive music at noon, transitioning with soft and warm music in the evening, and guiding rest with quiet and profound music at night. Geographically-appropriate protocol implementation fully considers the acoustic characteristics and cultural atmosphere of treatment spaces, creating musical sanctuaries amid urban hustle and bustle, and integrating natural sounds in rural environments. In the effect feedback stage, therapeutic effects are evaluated through multidimensional evaluation indicators, updating the knowledge base and optimizing algorithm models.

The innovation of this generation mechanism lies in achieving organic combination of static personalization and dynamic adaptation. Traditional personalized protocols are often static and rarely adjusted once formulated. The mechanism proposed in this research can dynamically optimize based on real-time feedback during the treatment process, better adapting to changes in individual states.

4. Application Prospects and Challenges

4.1 Clinical Application Prospects

AI-Powered music therapy under the "Three Categories of Etiological Factors System" principle demonstrates broad application prospects in multiple clinical fields. In mental health, it can provide

personalized adjunctive treatment for depression, anxiety disorders, post-traumatic stress disorder(PTSD), and other conditions, such as selecting bright and stable music for depressed patients [6] to gradually guide their emotions in positive directions, and providing secure musical environments for PTSD patients to help them rebuild emotional stability. In neurological rehabilitation, it can help stroke, Parkinson's disease, and Alzheimer's disease patients improve cognitive function and motor abilities, particularly through strongly rhythmic music stimulating motor neural circuits to improve gait and coordination. In pain management, it can serve as an effective non-pharmacological analgesic method, alleviating pain through music distraction and activation of endorphin systems. In child development, it assists in rehabilitation training for special needs children with autism and attention deficit hyperactivity disorder(ADHD), promoting social interaction and cognitive development through structured musical activities.

Compared to traditional music therapy, AI-Powered personalized protocols can significantly improve treatment precision and effectiveness. Through real-time monitoring and dynamic adjustment, problems in the treatment process can [7] be promptly identified and addressed, reducing adverse reactions. Meanwhile, AI systems can accumulate and learn from numerous treatment cases, continuously optimizing treatment strategies and achieving rapid accumulation and transmission of experience.

4.2 Technology Integration Challenges

Despite the established theoretical framework, practical application still faces numerous technical challenges. First is the data standardization issue—data from different sources varies in format and quality, requiring establishment of unified data standards and quality control systems. Second is algorithm interpretability—the decision processes of complex algorithms like deep learning are difficult to explain, potentially affecting acceptance by medical professionals and patients.

System integration is also an important challenge. Music therapy systems need to interface with existing medical information systems and electronic health record systems to achieve data interconnection. This requires solving a series of technical and management issues including interface standards, data security, and privacy protection.

Additionally, AI model generalization capability needs improvement. Due to extreme individual differences, models trained on limited samples may not adapt well to new individuals. More robust learning algorithms need to be researched to improve model generalization performance.

4.3 Ethical and Social Considerations

AI-Powered music therapy involves multiple ethical and social issues. Data privacy is the primary concern—physiological, psychological, and behavioral data collected by the system are all sensitive information, requiring establishment of strict data protection mechanisms. Informed consent is also an important ethical requirement—patients should fully understand AI system operating principles and potential risks. Algorithmic bias is another issue requiring attention. If training data contains biases, AI systems may generate discriminatory treatment recommendations. Data representativeness and diversity must be ensured, with regular reviews of algorithmic fairness.

The balance of human-machine relationships also deserves deep consideration. While AI can provide precise technical support, the humanistic care and emotional support in music therapy remain irreplaceable. The auxiliary role of AI needs to be clarified, maintaining therapists' leading position in the treatment process.

4.4 Theoretical Innovation and Practical Significance

This research achieves multiple innovations at the theoretical level. First, it systematically introduces the TCM principle of "Three Categories of Etiological Factors System" into the music therapy field for the first time, constructing a theoretical framework integrating Eastern and Western medical wisdom. This not only enriches the theoretical system of music therapy but also provides new paradigms for modern applications of TCM theory.

Second, it proposes a multidimensional, dynamic personalized treatment theoretical model. While traditional personalized medicine often focuses on single dimensions or static characteristics, the three-dimensional dynamic model constructed in this research is more comprehensive and flexible, better adapting to complex and changing treatment needs.

Third, it establishes the theoretical foundation for deep integration of AI technology and music therapy. Beyond exploring technical applications of AI in music therapy, more importantly, it elucidates theoretical bases and mechanisms, providing theoretical support for AI medical development.

The research findings have important guiding significance for music therapy practice. They provide music therapists with systematic personalized treatment design methods, helping them better understand and apply the "Three Categories of Etiological Factors System" principle. They provide theoretical basis and technical roadmaps for medical institutions building intelligent music therapy centers.

For AI medical enterprises, this research provides design frameworks and key technical solutions for music therapy intelligent systems. Enterprises can develop specific products and services based on this framework, promoting industrialization development of music therapy. For policymakers, research results help formulate industry standards and regulatory policies for music therapy. Particularly in areas of AI application ethical norms, data security, and quality control, they provide theoretical basis and practical recommendations.

The theoretical construction methods, model design approaches, and technology integration strategies formed during the research process can provide references [8] for other research combining traditional medicine with modern technology. They particularly provide successful cases and experience in integrating traditional cultural wisdom with modern technology.

5. Future Development Directions

5.1 Theoretical Deepening Directions

Future development requires deeper exploration of the connotations of the "Three Categories of Etiological Factors System" principle. In treatment according to individual factors, explore how to construct unique music therapy spectrums based on individuals' life histories and musical experiences, forming "musical life chronicles" as individual archives. In treatment according to temporal factors, research how to grasp the different roles of micro-time (instantaneous emotional fluctuations), meso-time (daily rhythm changes), and macro-time (life stage transitions) in music therapy. In treatment according to geographical factors, deepen understanding of music geography and music anthropology, exploring healing mechanisms of music in different cultural backgrounds. By deeply integrating this traditional wisdom with modern music therapy theory, construct a music therapy system with Eastern characteristics.

5.2 Technology Development Trends

In practical application, further exploration of modern transformation of the "Three Categories of Etiological Factors System" principle is needed. Treatment according to individual factors requires establishing more detailed individual musical health archives, recording each person's music-related life imprints, from mothers' lullabies to adult emotional attachments, forming unique music therapy maps. Treatment according to temporal factors requires grasping multidimensional temporal rhythms, not only circadian biological clocks but also emotional tidal flows, seasonal Yin-yang wax and wane, and life's rising and falling transitions. Treatment according to geographical factors requires deep understanding of regional musical cultural genes, allowing therapeutic music to deeply resonate with patients' cultural roots, achieving true "music and medicine from the same source." Through appropriate technological support combined with humanistic care, music therapy can return to its essence—using music to warm hearts and heal body and mind.

6. Conclusion

This study constructs a theoretical framework for personalized pathways in receptive music therapy by integrating the TCM principle of "Three Categories of Etiological Factors System" with artificial intelligence technology, providing new theoretical perspectives and practical guidance for intelligent and precise development of music therapy.

The main research achievements include: First, establishing systematic mapping relationships of the "Three Categories of Etiological Factors System" principle in music therapy, clarifying specific connotations and application methods of the three dimensions—individual, temporal, and geographical factors—in music therapy; Second, constructing AI technology-based multidimensional assessment models and dynamic optimization mechanisms, achieving intelligent generation and real-time adjustment of personalized treatment protocols; Third, designing technical implementation pathways including data collection, intelligent decision-making, and dynamic optimization modules, providing specific guidance for system development; Fourth, analyzing application prospects, challenges faced, and development directions of the theoretical framework, indicating directions for subsequent research and practical applications.

The research results have important significance for music therapy theory and practice. At the theoretical level, they achieve innovative integration of Eastern and Western medical wisdom, enriching theoretical systems of music therapy and precision medicine. At the practical level, they provide theoretical basis and technical solutions for developing intelligent music therapy systems, potentially improving accessibility and effectiveness of music therapy. At the methodological level, they demonstrate pathways and value of interdisciplinary fusion research, providing references for related field research.

Future research and applications need continuous efforts in theoretical deepening, technological innovation, standard formulation, and ethical norms, promoting AI-Powered personalized music therapy from theory to practice, from laboratory to clinical settings, ultimately benefiting patients. Through continuous exploration and innovation, intelligent music therapy under the "Three Categories of Etiological Factors System" principle is expected to become an important component of precision medicine and smart healthcare, making unique contributions to human health endeavors.

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