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A review of research on the application of music intervention in intervention for children with attention deficit hyperactivity disorder

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Abstract. Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder in children, mainly manifested by inattention, hyperactivity and impulsivity. In recent years, music therapy has gradually become an important research direction of adjunctive intervention for ADHD due to its potential effects on attention regulation, executive function and emotional support. This paper adopts the literature review method to sort out relevant studies on ADHD and music therapy, and analyzes the theoretical basis, possible mechanisms and research progress of music therapy in the intervention of children with ADHD. Meanwhile, combined with the development of digital therapeutics and mobile health, this paper further discusses the main types, functional characteristics and practical limitations of digital music intervention tools. On this basis, referring to commonly used digital health application evaluation frameworks such as MARS, ENLIGHT and the APA App Evaluation Model, this paper preliminarily proposes evaluation dimensions for digital music intervention tools targeting ADHD. Studies show that music therapy has certain application potential in improving attention regulation, executive function and emotional support of children with ADHD. However, existing studies still have limitations such as limited sample sizes, large differences in intervention forms and insufficient clinical evidence. Relevant digital products also have shortcomings in individualized design, evidence base, safety and child data protection. In the future, it is still necessary to combine real-user studies and clinical evaluations to further verify the actual effects and applicable boundaries of digital music intervention.

Keywords: attention deficit hyperactivity disorder, music therapy, digital music intervention, child intervention, application evaluation

1. Introduction

1.1. Research background

In recent years, the identification and intervention of neurodevelopmental problems in children and adolescents have gradually received extensive attention in the fields of medicine, psychology and education.

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Attention Deficit Hyperactivity Disorder (ADHD) is one of the common neurodevelopmental disorders in children and adolescents. Its core symptoms mainly include inattention, hyperactivity and impulsivity, which may further affect individuals' academic performance, interpersonal communication, as well as family and social functions [1, 2]. From the perspective of public health and educational support, ADHD is not only a clinical diagnosis issue, but also a practical topic involving child development, family burden and school support systems. The clinical practice guideline issued by the American Academy of Pediatrics clearly points out that the assessment and treatment of ADHD require collaboration among families, schools and clinical systems.

In the context of mainland China, ADHD also has high research and intervention value. A systematic review and meta-analysis targeting Chinese children and adolescents showed that the combined prevalence of ADHD among children and adolescents in China is approximately 6.26% [3]. A more recent national survey further suggests that ADHD and its comorbidities have epidemiological significance worthy of attention among school-age children aged 6 to 16 in China [4]. These studies indicate that ADHD is not a marginal problem in mainland China, but a psychological and behavioral health issue for children and adolescents on a considerable scale [3, 4].

According to data from the Hong Kong region of China, the demand for ADHD-related services is also noteworthy. The *Reference Framework for Preventive Care for Children in Primary Care Settings* issued by the Health Bureau of the Hong Kong SAR Government, citing local child health survey data, points out that the reported prevalence of ADHD among children aged 2 to 14 in Hong Kong, China is 0.7% [5]. Meanwhile, a document from the Legislative Council of the Hong Kong Special Administrative Region of China, citing statistics from the Hospital Authority for 2022/23, states that approximately 21,300 ADHD patients received treatment in the public hospital psychiatric system that year, of whom about 17,500 were children [6]. Although epidemiological calibers and medical service calibers cannot be directly equated, these data reflect from different aspects that there is a sustained demand for identification, referral and intervention of ADHD in the Hong Kong region of China [5, 6].

Currently, intervention approaches for ADHD have formed a comprehensive model dominated by pharmacotherapy, behavioral intervention and psychosocial support. Authoritative guidelines point out that intervention plans usually need to be comprehensively evaluated and individualized based on age stage, symptom severity, comorbidity, as well as family and school environments [1, 7]. Although existing interventions have clear value in improving core symptoms, they still have certain limitations in terms of long-term adherence, cross-context implementation and continuous support. Therefore, exploring adjunctive intervention methods with higher acceptability, participation and scenario adaptability has become an important extension direction for the comprehensive management of ADHD [7].

2. Definition of core concepts and theoretical basis

2.1. Attention Deficit Hyperactivity Disorder (ADHD)

Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder, mainly manifested by inattention, hyperactivity and impulsive behaviors that are inconsistent with the individual's age and developmental level. These symptoms usually persist and can significantly affect an individual's learning, daily life, interpersonal communication and social functioning. ADHD usually onsets in childhood and is one of the common psychological and behavioral problems in children and adolescents. Some symptoms can continue into adolescence and even adulthood [1, 8].

In terms of clinical manifestations, the core symptoms of ADHD mainly include two aspects: inattention, and hyperactivity-impulsivity. Among them, inattention is mainly manifested as difficulty in maintaining attention for a long time, easy distraction, carelessness in doing things, weak organizational skills, frequent forgetfulness, and difficulty in completing tasks that require sustained mental effort. Hyperactivity-impulsivity is mainly manifested as excessive activity, difficulty in staying quiet, excessive talking, difficulty in waiting, frequent interruption of others, and impulsive behavioral responses. Individuals may differ in symptom manifestations, so ADHD often presents with different clinical patterns in actual diagnosis [8].

Overall, ADHD is not simply "naughtiness" or "poor attention", but a disorder with a neurodevelopmental basis. Existing studies have shown that ADHD is related to abnormalities in brain structure, brain function and neurotransmitter systems. Its impact is not only reflected in attention control and behavior management, but also often involves multiple levels such as executive function, emotion regulation and social adaptation [2, 10]. Therefore, the understanding of ADHD should not only stay in the explicit behavioral manifestations, but also be comprehensively recognized combined with its developmental, persistent and functional impairment characteristics [2, 8, 10]. Table 1 sorts out the main presentation types of ADHD [8, 9].

Table 1. Presentation types of ADHD

ADHD Classification	Diagnostic Criteria	Core Features	Summary
Predominantly Inattentive Presentation	Predominantly Inattentive Presentation	Difficulty maintaining attention, easy distraction, carelessness, weak organizational skills, forgetfulness, procrastination, difficulty completing tasks requiring sustained mental effort	Difficulties in attention control and executive function
Predominantly Hyperactive-Impulsive Presentation	Meets both sets of criteria for inattention and hyperactivity-impulsivity	Inability to sit still, excessive movement, talkativeness, difficulty waiting, frequent interruption of others, impulsive actions	Obvious overt behaviors, easier to be identified
Combined Presentation	Meets both sets of criteria for inattention and hyperactivity-impulsivity	Both difficulty in attention maintenance and obvious hyperactive-impulsive behaviors	The most typical and easily identifiable type

2.2. Definition of art therapy

Art therapy refers to a type of intervention method that uses art forms such as painting, music, dance and drama to help individuals express emotions, regulate psychology and improve functions in a professional supportive relationship. According to the definition of the American Art Therapy Association, art therapy is a professional mental health service that combines the creative process of art, psychological knowledge and therapeutic relationships, and can be used to support the mental health and well-being of individuals, families and groups [11]. Therefore, art therapy is not simply art activities or interest cultivation, but professional intervention carried out under certain goals.

Existing studies have pointed out that art activities often not only have aesthetic value, but also may have positive impacts on health and well-being through mechanisms such as sensory participation, emotional arousal, cognitive stimulation and social interaction [12]; for the professional development history of modern art therapy, see Robb [13], Gussak and Rosal [14]. This means that the role of art therapy is not limited to

"relaxing the mood", but may play a comprehensive role in emotional support, cognitive promotion and social adaptation.

For children, art therapy has favorable applicability. As children are not yet fully mature in verbal expression and emotion recognition, interventions relying solely on conversation often have limitations. Art media, however, can help children express their feelings, participate in activities and build interactive relationships in a more intuitive and vivid way. For this reason, art therapy has received increasing attention in children's psychological support and adjunctive intervention.

Among different forms of art therapy, music therapy is particularly suitable for intervention needs of children due to its characteristics of rhythm, structure, repetitiveness and interactivity. Compared with other art media, music can not only attract children's participation with low language burden, but also provide support for attention regulation, behavior control and emotional expression through rhythmic cues, emotional arousal and activity organization. For children with ADHD, these characteristics make music therapy of high research value in adjunctive intervention. Therefore, on the basis of clarifying the basic connotation of art therapy, it is necessary to further explain the concept, characteristics and intervention methods of music therapy.

2.3. Definition of music therapy

Music therapy is an important branch of art therapy. It refers to a systematic intervention method that uses music and related activities to promote improvements in individuals' cognition, emotion, behavior, social interaction and physical function under clear guidance of goals [15]. Different from simply "listening to music for relaxation" in daily life, music therapy emphasizes the role of music in professional relationships and intervention processes, and has clear goal orientation, process design and evaluation requirements.

In terms of connotation, music therapy not only focuses on music itself, but also attaches importance to individuals' participation in music experience and the interactive relationship developed between them and the therapist. Bruscia [15] pointed out that music therapy is a systematic intervention process, in which therapists use music experience and the relationship developed therefrom as the driving force for change to help individuals achieve health goals. This definition indicates that the core of music therapy is not just "using music", but transforming music into a medium with intervention significance under professional support.

In terms of implementation methods, music therapy can usually be divided into two categories: receptive and active. Receptive music therapy mainly includes methods such as listening to music, music relaxation and guided imagery, focusing on helping individuals stabilize their emotions, regulate arousal levels or maintain attention states through music experience. Active music therapy includes forms such as singing, rhythm imitation, musical instrument playing, improvisation and movement scoring, with more emphasis on individuals' participation, expression and interaction in activities [15]. For children, active music activities tend to improve participation, while receptive activities have certain advantages in creating a stable and supportive experience environment.

The importance attached to music therapy in children's adjunctive intervention is closely related to the unique attributes of music itself. First of all, music is rhythmic and structural, which can provide clear external cues for activity organization and attention maintenance. Secondly, music has strong emotional arousal and expressive functions, which help individuals identify, experience and regulate emotions. Thirdly, music activities are often accompanied by feedback, imitation, turn-taking and cooperation, which gives it unique advantages in promoting interaction, enhancing sense of participation and maintaining motivation. For these reasons, music therapy has gradually gained more attention in the fields of child development support, special education and psychological-behavioral intervention.

For children with ADHD, the value of music therapy is particularly reflected in its possible help for attention regulation, executive function support, behavior organization and emotion regulation. Since children with ADHD generally have problems such as difficulty in maintaining attention, insufficient impulse control and high activity levels, the rhythmic cues, repetitive structures and interactive feedback contained in music may provide a more attractive and acceptable adjunctive intervention method for them. Therefore, music therapy is not an ordinary activity divorced from the characteristics of ADHD symptoms, but a potential support path corresponding to the core difficulties of ADHD.

Music therapy is a systematic intervention process, in which therapists use music experience and the relationship developed through music experience as the driving force for change to help clients promote health.

Kenneth Bruscia defined music therapy as a systematic intervention process, in which therapists use music experience and the relationship developed therefrom as the driving force for change to help clients improve their health. This operational definition is not a single statement, but a causal system composed of six closely linked core dimensions [15].

First, the systematic process emphasizes that therapy must be goal-oriented, organized and standardized, rather than random or accidental experience. It includes three key stages: assessment, treatment and evaluation, reflecting the scientific and procedural nature of clinical work.

Second, music therapy is an intervention with therapeutic purposes, meaning that therapy must be directed to solve existing conditions to trigger change. Intervention must meet three criteria: the client has a need for external help, the intervention has a clear purpose, and it must be implemented in the context of the therapist-client relationship.

Third, music therapy must have the role of a therapist, that is, the therapist related to the client as mentioned in the second point. Here, two basic models are distinguished: "music as therapy" where music plays a leading role, and "music in therapy" where the therapist plays a leading role.

Fourth, music therapy is oriented to clients with health needs, and its treatment targets are people with health, developmental, psychological, behavioral or social adaptation needs.

Fifth, music therapy also takes promoting health as the ultimate therapeutic goal. It adopts a holistic perspective, holding that it includes both "disease warning" of eliminating diseases and "health promotion" of enhancing personal potential, aiming to realize the overall harmony between individuals and their social, cultural and environmental backgrounds.

Finally, the use of music experience is the unique hallmark of therapy. Its themes include four basic methods: improvisation, re-creation (performance/singing), composition and reception. In therapy, music is not only an object, but also a multi-dimensional experience involving people, processes, products and environments, with the core of creating meaning and beauty. Relationship dynamics are the key to change.

Through relational music, clients will develop capacities at the levels of introspection, inner musicality, interpersonal interaction, inter-musicality and socio-culture. These relational dimensions correspond to music experience, similar to the dynamic model in a chemical reaction system, and jointly drive positive health-related changes. They constitute the theoretical cornerstone of music therapy as an independent discipline, distinguishing it from daily music activities or single auxiliary rehabilitation means [15].

3. Neural mechanisms of music intervention for ADHD

3.1. Effects of music on the attentional system

Among individuals diagnosed with ADHD, there is a significant association between musical experience and enhanced cognitive performance in both musicians and non-musicians. People with music learning experience score significantly higher in the Digit Symbol Coding Test and the Symbol Search Test, both of which are designed to assess visuospatial processing speed, working memory and attention [16]. These tests together constitute the Processing Speed Index, one of the four main indices of the Wechsler Adult Intelligence Scale (WAIS), and a key component of intelligence. This index particularly reflects an individual's ability to process simple or routine visual information quickly and efficiently. Impairments in perceptual speed, psychomotor speed and incidental learning are common in children, adolescents and adults diagnosed with ADHD. The results of this study indicate that music experience has a positive effect on individuals' perceptual processing speed.

Previous research results have shown that early access to instrumental skill learning and long-term piano or guitar training are significantly associated with improvements in various cognitive functions in adults diagnosed with ADHD. This association is reflected in a range of cognitive abilities from basic to more complex skills, including sustained attention, visuospatial processing, processing speed, writing movement speed, detail discrimination, working memory, auditory recall, reaction inhibition and cognitive flexibility (shifting ability). A large part of these skills belong to the category of executive function, which affects quality of life in multiple domains [16].

The complex switching task is designed to assess higher-level aspects of executive function. It requires a great deal of cognitive and attentional load, demanding rapid alternation between two mental sets or rules to facilitate rapid and accurate response generation. In the study, the musician group outperformed the non-musician group, with significantly lower error rates indicating that music experience enhances the advanced cognitive function of rule switching. Importantly, although musicians had longer reaction times, they exhibited lower reaction time variability. Reaction time variability is considered an indicator reflecting key characteristics of the etiology of ADHD [17, 18]. These results suggest that music has a positive effect on cognitive and motor details, which provides a theoretical basis for subsequent music intervention.

3.2. Effects of music on executive functions

A notable feature of neurocognitive deficits in patients with ADHD is the impairment of executive function control, which is a general term covering inhibitory control, working memory and cognitive flexibility [19]. Compared with normally developing peers, patients with ADHD usually perform worse on executive function tasks [20, 21]. The Cognitive-Energetic Model [22] and the Dual Pathway Model [23] are relatively mainstream academic viewpoints, both of which emphasize the role of executive function deficits in ADHD symptoms. Therefore, improvements in brain regions related to executive function will also alleviate ADHD symptoms. Music intervention, through rhythm-based tasks and auditory stimulation, activates brain regions involved in executive function (such as the prefrontal cortex), and has the potential to enhance executive function, thereby alleviating ADHD symptoms [24].

Several studies have shown that music intervention can improve executive function in patients with ADHD, especially inhibitory control. For example, listening to filtered Mozart music and relaxing Turkish hymns can improve inhibitory control in adolescents with ADHD [25]; participation in structured and improvisational activities can significantly improve inhibitory control and ADHD symptoms in adolescents [26]; gamified rhythm training has improved inhibitory control in children with ADHD [27].

Overall, these studies provide preliminary evidence for the impact of music intervention on executive function in ADHD.

3.3. Effects of music on emotion regulation and the reward system

Difficulty in emotion management is also a characteristic of patients with ADHD [28, 29]. Emotion is mainly composed of affect and mood: affect refers to transient and intense psychological reactions triggered by specific people or things; mood is a diffuse state that lasts for a long time without clear direction. For patients with ADHD, both types of emotional states are highly prone to functional regulatory disorders. This lifelong emotion dysregulation is the key root cause of their impaired psychosocial functioning [30]. Patients with ADHD are prone to mood disorders, such as disruptive mood dysregulation disorder [28] and bipolar disorder [29]. Pharmacotherapy still has unsatisfactory effects in addressing emotion dysregulation in patients with ADHD [31], so other intervention measures are urgently needed to solve emotional problems.

Benefiting from the evolution of modern music therapy, behavioral studies have confirmed the regulatory effect of music on emotional states, and music therapy has thus become a new type of intervention with great potential in the future — that is, it can help alleviate the dilemma of emotion dysregulation in the ADHD population. From the perspective of neurobiochemistry, music intervention may fine-tune human time perception by affecting the dopamine system in the brain. As a signal conveying reward prediction error, dopamine can regulate the neural circuit responsible for time processing [32]. At the same time, music often integrates recurring melodies and sudden rhythmic changes. These characteristics can effectively stimulate the brain to secrete dopamine, thereby calming and improving the emotions of patients with ADHD [33].

4. Development and current status of digital music

4.1. Development background of digital intervention

In 2020, EndeavorRx became the first prescription Digital Therapeutic (DTx) specifically for children with ADHD approved by the U.S. Food and Drug Administration (FDA) [34], which uses video game experiences to enhance attention in such children. Subsequently, in June 2023, the International Organization for Standardization (ISO) released *ISO/TR 11147* [35], officially defining "digital therapeutics" as evidence-based, software-driven interventions for the prevention, management or treatment of medical conditions or diseases. This standardization by ISO helps the industry reach a global consensus on the scope and implementation of digital therapeutics.

In mental illnesses including ADHD, another strategy that holds promise for improving treatment adherence involves technology-based interventions. Mobile health (mHealth), relying on terminals such as smartphones, provides strong support for patient education, daily monitoring and adherence management by optimizing communication channels between patients and medical institutions as well as experts. In addition, this solution facilitates systematic tracking of treatment initiation, maintenance and clinical efficacy. Basic digital reminder functions such as taking medicine on time, attending appointments and refilling prescriptions have been proven to be practical and efficient means to improve patients' treatment adherence [36, 37].

4.2. Main types of digital music intervention apps

Digital music intervention is not a completely unified concept, meaning the definition of "APP" here is broader. Relevant studies appear in the forms of mobile music app, web app-based music, iPad-based music

therapy, technology-based music therapy tools, biofeedback music intervention, AI-assisted music therapy tools, etc. [38-47].

Therefore, this paper defines digital music intervention apps as "music intervention tools delivered via digital devices or digital platforms". According to their technical carriers and intervention mechanisms, they are classified into seven categories: general music playback, music therapy assistance, web-based/online intervention, tablet/iPad-based tools, rhythm training, biofeedback, and AI/generative music intervention.

4.3. Functional features of music therapy apps

Nowadays, the functions of digital music intervention tools are no longer limited to simple music playback, but are accelerating towards personalization, interactivity and digitalization. First of all, the most basic function of digital music therapy tools is to help users relieve stress and guide attention through music playback, interest matching and customized content [38, 39]. Second are interactive music activities. In intervention, some music therapy apps or digital tools introduce simple tasks such as rhythm practice and auditory-motor coordination. Such functions require users to stay sensitive to rhythmic beats and concentrate to respond in a timely manner, which is also related to attention control and executive function training [40, 43].

In addition to traditional "listening to music", some digital music intervention systems also integrate bioelectrical signal feedback, neurofeedback and artificial intelligence technology. For example, music content is dynamically adjusted according to users' real-time biological information (EEG/heart rate/respiration). The application of AI technology further facilitates user state recognition and personalized music recommendation [45], realizing the transformation of music therapy intervention from rigid fixed audio to more personalized forms [46, 47].

5. Evaluation criteria for digital music apps in ADHD treatment

5.1. Evaluation dimension design and app illustration

The evaluation framework is constructed by integrating commonly used tools including the Mobile App Rating Scale (MARS) for health apps, ENLIGHT for mobile and web-based eHealth interventions, the APA App Evaluation Model for mental health apps, and existing ADHD-specific app evaluation criteria [48, 49].

On this basis, several new evaluation dimensions are added. The final scale covers five dimensions: app accessibility and basic usability, music intervention characteristics, matching degree with ADHD symptoms, therapeutic potential and behavior change support, and safety and privacy.

Only a case analysis and recommendation is provided here. Brain.fm is the closest to a professional music intervention tool for ADHD, and most aligns with its advertised ADHD-related functions. The software has a dedicated mode for ADHD, enhances dopamine stimulation by allowing users to select preferred music genres, and performs exceptionally well in focus function, greatly reducing attention distraction and fatigue caused by regular or uninteresting music.

5.2. Correspondence between evaluation dimensions and ADHD subtypes

For the dimension of matching degree with ADHD symptoms, the scale is designed targeting the specific difficulties and intervention directions of three ADHD subtypes. For the predominantly inattentive type, evaluation focuses on whether the app provides attention training, task segmentation (Pomodoro Technique), rhythm prompts, and a concise UI design that reduces interference. For the predominantly hyperactive-

impulsive type, evaluation focuses on whether the app includes rhythmic movement, body control activities, impulse control training and timely feedback. For the combined type, evaluation focuses on whether the app simultaneously covers attention regulation, behavior control, emotion regulation and executive function enhancement.

In addition, dimensions are designed for common difficulties across ADHD populations: for executive function deficits, the app should support planning, reminders, progress tracking and goal management; for emotion regulation difficulties, the app should include relaxation music modules, breathing rhythm adjustment, emotion logging and soothing sounds; for sleep or anxiety problems, the app should provide sleep music and relaxation training, and maintain low sensory stimulation.

5.3. Evaluation scale

Table 2. Evaluation scale

Evaluation Dimension	Specific Evaluation Content
App Accessibility and Basic Usability	Engagement
	Functionality
	Aesthetics
	Information quality
	Subjective quality
Characteristics of Music Therapy Intervention	Richness of music type
	Rhythm activities
	Active music participation
	Availability of personalized music
	Availability of auditory-motor integration
Matching Degree with ADHD Symptoms	Predominantly inattentive type
	Predominantly hyperactive-impulsive type
	Executive function module
	Emotional regulation module
	Sleep/relaxation module
Therapeutic Potential and Behavior Change Support	Goal setting
	Feedback mechanism
	Progress tracking
	Reminder function
	Design for sustained use
Safety and Privacy	Privacy policy
	Child data protection
	Clinical evidence

Based on the MARS five-point scoring method, this study divides each evaluation index into five grades: excellent, good, acceptable, poor and insufficient (see Table 2), to improve the consistency and operability of cross-app comparison. Scores for each item are determined based on actual usage experience and functional

performance. A higher score indicates a higher degree of conformity of the app in the corresponding evaluation dimension.

6. Discussion and personal reflection

6.1. Discussion

Although offline music therapy has been developed for decades, it has been slow to gain public recognition due to limited understanding of the neural mechanisms behind behavioral changes during intervention. With the involvement of neuroscience, music therapy has gradually entered public view and become a potential adjunctive intervention option. In recent years, ADHD has raised public awareness of cranial nerve health. Along with common problems such as difficulty falling asleep, decreased emotional and attentional control, and frequent procrastination, music as a basic intervention method has been widely adopted, making "music affects attention" a widely recognized concept. Music software has emerged accordingly, but also brings many new problems.

For example, with a large number of non-personalized audio options, free choice itself becomes a behavior that increases cognitive load, which is particularly unfriendly to people with ADHD. Abundant choices will make users prioritize trying new content over focusing on completing tasks. In addition, some music may make users feel tired and sleepy while soothing emotions, and many users confuse sleep-aid music with attention-enhancing music. Most current software only focuses on relaxation effects rather than targeted intervention, which instead increases resistance to learning.

Regarding task tracking and positive feedback, mandatory countdown and rigid task naming can also cause certain pressure. On the contrary, positive timing can reduce such pressure. With progress tracking and timely feedback mechanisms, optional or default positive timing can better encourage users to complete focused sessions and maintain task continuity.

6.2. Limitations and personal reflection

At the initial stage, the understanding of music therapy stayed at the intuitive level of "listening to music can relax and improve attention". In the process of literature review and theoretical sorting, the authors gradually realized that authentic music therapy is not simply playing music, but a systematic method with clear goals, standardized assessment, structured intervention process and professional therapeutic relationship. Especially when analyzing ADHD-related attention deficits, executive function difficulties, emotion regulation problems and reward mechanisms, the authors found a strong connection between music intervention and neuroscience, and further recognized the importance of interdisciplinary research.

When evaluating digital music apps, the authors found a gap between the functional claims of commercial software and their actual intervention value. Although many apps emphasize functions such as focus, relaxation or sleep support, they are not necessarily designed for the core symptoms of children with ADHD, nor do they have sufficient clinical evidence. Therefore, evaluation should not only focus on interface design and user experience, but also make comprehensive judgments combined with safety and scientific evidence.

This study still has shortcomings: the evaluation dimensions are not comprehensive enough, the sample selection of apps is limited, and there is a lack of data support from real children with ADHD. Future research can combine behavioral experiments to further verify the actual effects of digital music intervention on attention, executive function and emotion regulation of children with ADHD.

7. Conclusion

This study sorts out the theoretical basis, neural mechanisms and digital product application status of music therapy in the intervention of children with ADHD.

As a common neurodevelopmental disorder, ADHD has a considerable scale of unmet identification and intervention needs in both mainland China and the Hong Kong region of China. The traditional comprehensive intervention model faces certain limitations in terms of long-term sustainability and cross-scenario implementation.

This paper demonstrates the intervention effects of art therapy and music therapy on ADHD from both theoretical and neural mechanism perspectives. Music therapy is not a random recreational activity. From the perspective of neural mechanisms, long-term instrumental training and rhythm training can activate brain regions such as the prefrontal cortex, thereby improving executive function in patients with ADHD. Meanwhile, such training can enhance sustained attention and improve inhibitory control. Melodic and rhythmic changes in music can also promote dopamine release, thus regulating emotional control and alleviating emotion dysregulation.

Against the background of the development of digital therapeutics and mobile health, many apps on the market claim to affect attention or even improve ADHD symptoms. Referring to mature evaluation scales such as MARS, ENLIGHT and APA, this study constructs a comprehensive evaluation framework covering multiple dimensions including music intervention characteristics and ADHD symptom matching degree.

In general, this paper combines neural mechanism theory with digital product evaluation, explores the construction and improvement of a specialized evaluation scale, and enriches research on the digital application direction of music therapy for ADHD.

References

[1] Wolraich, M. L., Hagan Jr, J. F., Allan, C., Chan, E., Davison, D., Earls, M., ... & Subcommittee on Children and Adolescents with Attention-Deficit/Hyperactive Disorder. (2019). Clinical practice guideline for the diagnosis, evaluation, and treatment of attention-deficit/hyperactivity disorder in children and adolescents. *Pediatrics, 144*(4), e20192528.

[2] World Health Organization. (2024). *Clinical descriptions and diagnostic requirements for ICD-11 mental, behavioural and neurodevelopmental disorders*. World Health Organization.

[3] Wang, T., Liu, K., Li, Z., Xu, Y., Liu, Y., Shi, W., & Chen, L. (2017). Prevalence of attention deficit/hyperactivity disorder among children and adolescents in China: A systematic review and meta-analysis. *BMC Psychiatry, 17*, 32. https://doi.org/10.1186/s12888-016-1187-9

[4] Wang, T., Liu, K., ...Chen, L. (2017). Prevalence of attention deficit/hyperactivity disorder among children and adolescents in China: A systematic review and meta-analysis. *BMC Psychiatry*, *17*(1), 32.

[5] Health Bureau, Hong Kong SAR Government. (2023). *Preventive care for children in primary care settings: Reference framework.* https://www.healthbureau.gov.hk/pho/rfs/src/pdfviewer/web/pdf/preventivecareforchildren/en/02_CoreDocument/13_en_ref_framework_children.pdf

[6] Legislative Council of the Hong Kong Special Administrative Region. (2023). *LC Paper No. CB(2)815/2023(08): Written submission on support for persons with attention deficit/hyperactivity disorder*. https://www.legco.gov.hk/yr2023/english/panels/ws/papers/ws20230905cb2-815-8-e.pdf

[7] National Institute for Health and Care Excellence. (2018). *Attention deficit hyperactivity disorder: Diagnosis and management (NICE Guideline NG87)*. https://www.nice.org.uk/guidance/ng87

[8] American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders (5th ed., text rev.; DSM-5-TR)*. American Psychiatric Association Publishing. https://doi.org/10.1176/appi.books.9780890425787

[9] Substance Abuse and Mental Health Services Administration. (2016, June). *DSM-5 changes: Implications for child serious emotional disturbance*. Chapter 3, DSM-5 child mental disorder classification. https://www.ncbi.nlm.nih.gov/books/NBK519712/

[10] Cortese, S., Aoki, Y. Y., Itahashi, T., Castellanos, F. X., & Eickhoff, S. B. (2021). Systematic review and meta-analysis: Resting-state functional magnetic resonance imaging studies of attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 60*(1), 61–75. https://doi.org/10.1016/j.jaac.2020.08.014

[11] American Art Therapy Association. (n.d.). About art therapy. *American Art Therapy Association*. https://arttherapy.org/about-art-therapy/

[12] Fancourt, D., & Finn, S. (2019). *What is the evidence on the role of the arts in improving health and well-being? A scoping review* [Internet]. Copenhagen: WHO Regional Office for Europe. (Health Evidence Network synthesis report, No. 67.) Available from: https://www.ncbi.nlm.nih.gov/books/NBK553773/

[13] Robb, M. (2012). The history of art therapy at the National Institutes of Health. *Art Therapy, 29*(1), 33–37. https://doi.org/10.1080/07421656.2012.648097

[14] Gussak, D. E., & Rosal, M. L. (Eds.). (2025). *The Wiley handbook of art therapy*. John Wiley & Sons.

[15] Bruscia, K. E. (1998). *Defining music therapy* (2nd ed.). Barcelona Publishers.

[16] Raz, S. (2024). Enhancing cognitive abilities in young adults with ADHD through instrumental music training: A comparative analysis of musicians and non-musicians. *Psychological Research, 89*(1). https://doi.org/10.1007/s00426-024-02048-2

[17] Adamo, N., Di Martino, A., Esu, L., Petkova, E., Johnson, K., Kelly, S., Castellanos, F. X., & Zuddas, A. (2014). Increased reaction-time variability across different cognitive tasks in children with ADHD. *Journal of Attention Disorders, 18*(5), 434–446. https://doi.org/10.1177/1087054712439419

[18] Kofler, M. J., Rapport, M. D., Sarver, D. E., Raiker, J. S., Orban, S. A., Friedman, L. M., & Kolomeyer, E. G. (2013). Reaction time variability in ADHD: A meta-analytic review of 319 studies. *Clinical Psychology Review, 33*(6), 795–811. https://doi.org/10.1016/j.cpr.2013.06.001

[19] Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–160. https://doi.org/10.1146/annurev-psych-113011-143750

[20] Cortese, S., Kelly, C., Chabernaud, C., Proal, E., Di Martino, A., Milham, M. P., & Castellanos, F. X. (2012). Toward systems neuroscience of ADHD: A meta-analysis of 55 fMRI studies. *American Journal of Psychiatry*, *169*(10), 1038–1055. https://doi.org/10.1176/appi.ajp.2012.11101521

[21] Rubia, K. (2018). Cognitive neuroscience of attention deficit hyperactivity disorder (ADHD) and its clinical translation. *Frontiers in Human Neuroscience, 12*, 100. https://doi.org/10.3389/fnhum.2018.00100

[22] Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive-energetic model. *Biological Psychiatry, 57*, 1248–1255. https://doi.org/10.1016/j.biopsych.2004.09.010

[23] Sonuga-Barke, E. J. S. (2005). Causal models of attention-deficit/hyperactivity disorder: From common simple deficits to multiple developmental pathways. *Biological Psychiatry, 57*, 1231–1238. https://doi.org/10.1016/j.biopsych.2004.09.008

[24] Luo, Z., & Zhang, D.-W. (2025). Rhythms of relief: Perspectives on neurocognitive mechanisms of music interventions in ADHD. *Frontiers in Psychology, 16*. https://doi.org/10.3389/fpsyg.2025.1476928

[25] Dursun, P., Fidan, U., & Karayagiz, S. (2021). Probable role of listening therapy in the management of ADHD symptoms: Three case studies. *Current Psychology, 40*(2), 4219–4234. https://doi.org/10.1007/s12144-021-01419-x

[26] Rickson, D. J. (2006). Instructional and improvisational models of music therapy with adolescents who have attention deficit hyperactivity disorder (ADHD): A comparison of the effects on motor impulsivity. *Journal of*

Music Therapy, 43(1), 39–62. https://doi.org/10.1093/jmt/43.1.39

[27] Jamey, K., Laflamme, H., Foster, N. E. V., Rigoulot, S., Kotz, S. A., & Bella, S. D. (2024). Can you beat the music? Validation of a gamified rhythmic training in children with ADHD. *Psychiatry and Clinical Psychology*. https://doi.org/10.1101/2024.03.19.24304539 (preprint).

[28] Mulraney, M., Schilpzand, E. J., Hazell, P., Nicholson, J. M., Anderson, V., Efron, D., et al. (2016). Comorbidity and correlates of disruptive mood dysregulation disorder in 6–8-year-old children with ADHD. *European Child & Adolescent Psychiatry, 25*(3), 321–330. https://doi.org/10.1007/s00787-015-0738-9

[29] Sandstrom, A., Perroud, N., Alda, M., Uher, R., & Pavlova, B. (2021). Prevalence of attention-deficit/hyperactivity disorder in people with mood disorders: A systematic review and meta-analysis. *Acta Psychiatrica Scandinavica, 143*(4), 380–391. https://doi.org/10.1111/acps.13283

[30] Shaw, P., Stringaris, A., Nigg, J., & Leibenluft, E. (2014). Emotion dysregulation in attention deficit hyperactivity disorder. *American Journal of Psychiatry, 171*(3), 276–293. https://doi.org/10.1176/appi.ajp.2013.13070966

[31] Lenzi, F., Cortese, S., Harris, J., & Masi, G. (2018). Pharmacotherapy of emotional dysregulation in adults with ADHD: A systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews, 84*, 359–369. https://doi.org/10.1016/j.neubiorev.2017.08.010

[32] Paton, J. J., & Buonomano, D. V. (2018). The neural basis of timing: Distributed mechanisms for diverse functions. *Neuron, 98*, 687–705. https://doi.org/10.1016/j.neuron.2018.03.045

[33] Gold, B. P., Pearce, M. T., Mas-Herrero, E., Dagher, A., & Zatorre, R. J. (2019). Predictability and uncertainty in the pleasure of music: A reward for learning? *Journal of Neuroscience, 39*, 9397–9409. https://doi.org/10.1523/JNEUROSCI.0428-19.2019

[34] Lin, J., & Chang, W.-R. (2025). Effectiveness of serious games as digital therapeutics for enhancing the abilities of children with attention-deficit/hyperactivity disorder (ADHD): Systematic literature review. *JMIR Serious Games, 13*, e60937. https://doi.org/10.2196/60937

[35] Carvalho, L. R., Haas, L. M., Zeni, G., Victor, M. M., Techele, S. P., Marrone Castanho, J., … Garrudo, A. (2023). Evaluation of the effectiveness of the FOCUS ADHD app in monitoring adults with attention-deficit/hyperactivity disorder. *European Psychiatry, 66*(1). https://doi.org/10.1192/j.eurpsy.2023.2422

[36] Hides, L., Dingle, G., Quinn, C., Stoyanov, S. R., Zelenko, O., Tjondronegoro, D., ... & Kavanagh, D. J. (2019). Efficacy and outcomes of a music-based emotion regulation mobile app in distressed young people: Randomized controlled trial. *JMIR mHealth and uHealth, 7*(1), e11482.

[37] Ford, J. H., II, Dodds, D., Hyland, J., & Potteiger, M. (2019). Evaluating the impact of music & memory's personalized music and tablet engagement program in Wisconsin assisted living communities: Pilot study. *JMIR Aging, 2*(1), e11599.

[38] Crowe, B. J., & Rio, R. (2004). Implications of technology in music therapy practice and research for music therapy education: A review of literature. *Journal of Music Therapy, 41*(4), 282-320.

[39] Guerrier, G., Abdoul, H., Jilet, L., Rothschild, P. R., & Baillard, C. (2021). Efficacy of a web app–based music intervention during cataract surgery: A randomized clinical trial. *JAMA Ophthalmology, 139*(9), 1007-1013.

[40] Finnerty, R., McWeeny, S., & Trainor, L. (2023). Online group music therapy: Proactive management of undergraduate students' stress and anxiety. *Frontiers in Psychiatry, 14*, 1183311.

[41] Knight, A. (2013). Uses of iPad® applications in music therapy. *Music Therapy Perspectives, 31*(2), 189-196.

[42] Silveira, T. M., Tamplin, J., Dorsch, S., & Barlow, A. (2018). Let's improvise!: iPad-based music therapy with functional electrical stimulation for upper limb stroke rehabilitation. *Australian Journal of Music Therapy, 29*, 1-16.

[43] Wei, Q., & He, W. (2026). The application of AI-assisted music therapy tools in mental health interventions. *Frontiers in Psychology, 17*, 1741463.

[44] Choi, Y. J., & Lee, N. R. (2025). Using a mobile app comprising neurofeedback-based meditation and binaural beat music to treat PTSD symptoms: A qualitative analysis. *Digital Health, 11*, 20552076241311053.

[45] Ferguson, A., Castellanos, C., & Pasquier, P. (2023). Digital music interventions for stress with bio-sensing: A survey. *Frontiers in Computer Science, 5*, 1165355.

[46] Stoyanov, S., Hides, L., Kavanagh, D., Zelenko, O., Tjondronegoro, D., & Mani, M. (2015). Mobile app rating scale: A new tool for assessing the quality of health mobile apps. *JMIR Mhealth Uhealth, 3*(1), e27. https://mhealth.jmir.org/2015/1/e27

[47] Baumel, A., Faber, K., Mathur, N., Kane, J. M., & Muench, F. (2017, March 21). Enlight: A comprehensive quality and therapeutic potential evaluation tool for mobile and web-based eHealth interventions. *Journal of Medical Internet Research, 19*(3), e82. https://doi.org/10.2196/jmir.7270

[48] Powell, L., Parker, J., & Harpin, V. (2017, October 13). ADHD: Is there an app for that? A suitability assessment of apps for the parents of children and young people with ADHD. *JMIR Mhealth Uhealth, 5*(10), e149. https://doi.org/10.2196/mhealth.7941

[49] Gasteiger, N., Dowding, D., Norman, G., McGarrigle, L., Eost-Telling, C., Jones, D., … O'Connor, S. (2023). *Conducting a systematic review and evaluation of commercially available mobile applications (apps) on a health-related topic: The TECH approach and a step-by-step methodological guide*. https://doi.org/10.1200/rs.3.rs-2647200/v1