

The Emotional Regulation Effects of Music Listening Experience on Running Performance: Mechanisms and Applications

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Abstract: *This research paper systematically investigates the emotional regulation effects of music listening on running performance through the theoretical lens of music psychology. By integrating perspectives from emotional psychology, cognitive psychology, and sports psychology, this study develops a comprehensive framework to analyze how musical elements - including tempo (BPM), rhythm, meter, and timbre - elicit synesthetic responses that subsequently modulate emotional states during running activities. The investigation specifically examines the psychological mechanisms through which music influences running performance, incorporating both theoretical analysis and practical applications. Through detailed examination of running scenarios and emotional regulation processes, this research demonstrates how synchronized music can optimize athletic performance by regulating emotional states, reducing perceived exertion, and enhancing motor coordination. The findings provide significant implications for designing music-based interventions to improve running efficiency and emotional experience, while establishing robust theoretical foundations for practical applications in sports psychology.*

Keywords: *Music Listening Experience; Emotional Regulation Effect; Running; Influence Mechanism*

1. Introduction

Music psychology provides the fundamental theoretical foundation for understanding how auditory stimuli influence human emotional states and physical performance. The interdisciplinary nature of this research necessitates integration with emotional psychology, cognitive psychology, and particularly sports psychology to comprehensively elucidate music's impact on running performance^[1]. This paper establishes music psychology as the core analytical framework while systematically incorporating relevant theories from complementary psychological disciplines. The conceptualization of music listening as essentially a synesthetic experience forms the cornerstone of our analytical approach. This perspective posits that auditory processing of musical elements automatically triggers cross-modal associations that influence emotional, cognitive, and motor systems^[2]. The complex interplay between musical characteristics and human psychology manifests particularly prominently in running contexts, where music's potential to regulate emotions and enhance performance has been consistently demonstrated across numerous empirical studies.

2. Theoretical Foundations in Music Psychology

2.1 Fundamental Principles of Music Psychology

Music psychology examines how humans perceive, process, and respond to musical stimuli, focusing particularly on the emotional and cognitive mechanisms underlying these processes. The discipline's core premise recognizes music as a structured temporal art form that systematically engages multiple psychological systems simultaneously^[3]. The processing of musical elements occurs through both bottom-up sensory mechanisms and top-down cognitive interpretations, creating a complex network of psychological responses. The concept of musical expectancy represents a central principle in music psychology. According to Meyer's (1956) seminal theory, music generates emotional responses through the creation, fulfillment, or violation of listener expectations. These expectations develop through exposure to musical systems and their inherent statistical regularities^[4]. When musical patterns align with established cognitive schemata, they produce positive affective states; when they deviate in controlled ways, they generate interest and engagement; when they violate expectations excessively,

they may cause discomfort or confusion.

This research is fundamentally grounded in the principles of music psychology, which provides the essential theoretical soil for all subsequent analysis. Every derivation of psychological mechanisms, validation of effects, and design of practical applications originates from this core discipline. The analysis of musical elements—BPM, rhythm, meter, timbre, melody, and harmony—and their subsequent impact on the runner's mind is strictly framed within the established paradigms of how the human brain perceives, processes, and responds to musical structures. This foundation is non-negotiable; it is the lens through which the interdisciplinary integration with emotional, cognitive, and sports psychology is filtered and interpreted. The mechanisms of emotional regulation during running are, therefore, not general psychological phenomena but are specifically conceptualized as outcomes of structured musical input as defined by music psychology^[5].

2.2 Music as Synesthetic Experience

The synesthetic nature of music listening constitutes a fundamental aspect of our theoretical framework. Synesthesia in this context refers to the automatic cross-modal associations triggered by musical stimuli, where auditory input generates corresponding sensations in other modalities. For instance, rising pitch patterns often elicit sensations of upward spatial movement, while increasing tempo typically produces feelings of accelerated motion or urgency. This synesthetic processing occurs through both low-level neural mechanisms and higher-level cognitive associations. The neurological basis involves co-activation of auditory processing regions with areas responsible for processing other sensory modalities, particularly visual and motor cortices. Simultaneously, cognitive associations develop through repeated experiences pairing specific musical characteristics with particular contexts, emotions, or physical sensations. These dual pathways—neural and cognitive—work synergistically to produce the rich, multidimensional experience of music listening^[6]. The synesthetic model explains why specific musical elements consistently evoke particular psychological and physiological responses during running. For example, low-frequency sounds with gradual amplitude envelopes typically feel "heavy" or "powerful," while high-frequency sounds with sharp attacks feel "light" or "energetic." These cross-modal associations form the foundation for music's ability to influence emotion, cognition, and motor behavior during running activities.

The conceptualization of music listening as essentially a synesthetic experience forms the cornerstone of our analytical approach to emotional regulation. This perspective posits that the auditory processing of musical elements automatically triggers cross-modal associations, or synesthesia, which is the primary vehicle for psychological influence. It is not merely "hearing" but a whole-body feeling: the perception of a rising pitch (a musical element) may elicit a synesthetic sensation of upward spatial movement or increasing effort, which then translates into an emotional state of anticipation or heightened arousal. This synesthetic processing is the fundamental mechanism. All emotional regulation effects discussed in this paper—whether during pre-run preparation, the main running activity, or post-run recovery—are initiated through this synesthetic gateway. The analysis of any musical feature must therefore answer the question: "What specific synesthetic sensation does this element evoke, and how is that sensation channeled into an emotional state relevant to the runner?"

3. Musical Elements and Their Psychological Correlates in Running

3.1 Tempo (BPM) Analysis and Running Performance

Tempo, quantified as Beats Per Minute (BPM), represents the fundamental pace of musical pieces, defined as the speed of beat progression or the temporal distance between consecutive beats. From a psychological perspective, tempo serves as a primary driver of physiological arousal and motor synchronization during running. Research consistently demonstrates that higher BPM counts generally increase heart rate, respiration rate, and overall activation level, while lower BPM counts produce opposite effects. The psychological impact of tempo operates through multiple mechanisms during running. First, neural entrainment processes cause biological rhythms to synchronize with musical beats, particularly in the 120-180 BPM range that corresponds with typical running cadences. Second, tempo influences perceived energy level through associative learning, as faster tempi typically accompany high-energy situations in both musical and non-musical contexts. Third, tempo affects cognitive processing speed, with faster tempi generally promoting quicker reaction times though potentially reducing precision in complex tasks. In running contexts, tempo-beat synchronization

represents perhaps the most direct application of music psychology. When musical BPM matches or slightly exceeds a runner's natural stride frequency, it can increase work output, enhance movement efficiency, and prolong endurance. The optimal tempo range varies according to running intensity: warm-up activities typically benefit from 100-120 BPM, moderate running from 120-140 BPM, and high-intensity running from 140-180 BPM.

3.2 Rhythm and Meter Psychology in Running Context

Rhythm, defined as the patterned arrangement of note durations creating distinct temporal structures, interacts with running psychology through its influence on expectation, attention, and motor coordination. Different rhythmic patterns produce varying psychological effects during running: simple, repetitive rhythms typically induce relaxation and automatic movement, while complex, unpredictable rhythms generally increase cognitive engagement and attention. Meter, conceptualized as "musical breathing," provides the organizational framework for rhythmic patterns. Duple meter (two beats per cycle) creates a stable, marching-like sensation that facilitates steady, consistent running rhythm. Triple meter (three beats per cycle) produces a swaying, waltz-like quality that encourages fluid, graceful motion but may be less suitable for maintaining consistent running pace. Quadruple meter (four beats per cycle) offers balanced stability with moderate complexity, making it particularly versatile for various running intensities. The compound meter of 8/6 represents a special case worthy of particular attention in running contexts. As a derived duple meter with ternary subdivisions, 8/6 combines the structural stability of duple organization with the flowing quality of triple patterns. This unique combination typically produces relaxed yet engaged psychological states, making it particularly suitable for recovery runs or moderate-intensity endurance training requiring both consistency and adaptability.

3.3 Multidimensional Musical Features and Emotional Regulation

Beyond tempo and rhythm, numerous additional musical elements contribute to emotional regulation during running. Melodic contour—the pattern of pitch ascents and descents—systematically influences emotional states and spatial associations. Rising melodies typically generate increasing tension and positive arousal, while descending melodies generally produce relaxation and resolution. These directional patterns activate corresponding spatial metaphors in cognition, influencing perceived physical effort and motivational states during running. Harmonic structure represents another crucial dimension for emotional regulation. Consonant harmonies—characterized by simple mathematical frequency ratios—typically feel stable, pleasant, and reassuring during strenuous running. Dissonant harmonies—featuring complex frequency relationships—generally create tension, uncertainty, and cognitive engagement, which may be beneficial for maintaining alertness during long-distance running but potentially counterproductive for relaxation-focused runs. Timbre, the distinctive tonal color of musical sounds, conveys rich emotional information through both innate acoustic properties and learned associations. Bright timbres with prominent high frequencies typically feel energetic, alert, and precise, while dark timbres with attenuated highs generally feel calm, warm, and substantial. These timbral characteristics interact with other musical elements to create complex emotional signatures that influence running experience through mood regulation and attention modulation.

3.4 Compound Synesthetic Effects for Emotional Regulation

The emotional regulation achieved through music listening is rarely the product of a single musical element but rather the compound result of multiple elements working in concert to create a unified synesthetic experience. The following analysis delineates how key elements contribute to this composite effect:

BPM (Tempo): Defined as the speed of the beat progression, or the temporal distance between consecutive beats, BPM is a primary driver of the synesthetic sensation of pace and kinetic energy. A high BPM (e.g., 160 BPM) creates a synesthetic feeling of urgency and rapid movement, directly increasing physiological arousal and generating emotions of excitement or intensity, ideal for high-intensity running intervals. Conversely, a low BPM (e.g., 100 BPM) synesthetically feels like slow, deliberate motion, promoting calmness and reducing anxiety, suitable for a cool-down.

Rhythm: As the patterned arrangement of long and short note durations, rhythm creates the synesthetic sensation of texture and complexity. Simple, repetitive rhythms induce a feeling of stability and automaticity, freeing cognitive resources and reducing mental fatigue. Complex, syncopated

rhythms create a synesthetic feeling of unpredictability and intellectual engagement, which can combat boredom but may be counterproductive if the running task itself is technically demanding.

Meter - The "Musical Breathing": Meter provides the foundational cyclical structure. As defined, a duple meter (2 beats per cycle) feels like two heartbeats for one breath—a stable, marching sensation that promotes consistent, grounded effort. A triple meter (3 beats per cycle) feels like three heartbeats per breath, creating a synesthetic sensation of swaying or waltzing, which can encourage a fluid, graceful running form but may lack the driving force for a power-based run. The special case of 8/6 compound meter, as a derivative of duple meter with ternary subdivisions, uniquely combines the structural stability of a two-beat foundation with the internal, synesthetic "swaying" quality of triplets. This results in a compound synesthetic experience that is both relaxed and engaged, perfect for maintaining a steady, enjoyable pace during long-distance runs.

Melodic Contour: The direction of a melody (ascending, descending, arch-like) creates a powerful synesthetic association with directionality and effort. A rising melody synesthetically feels like an increase in tension, effort, or aspiration, evoking emotions of hope and drive. A descending melody feels like a release, relaxation, or resolution, aiding in emotional recovery.

Harmonic Structure: Consonant harmonies (simple frequency ratios) synesthetically feel stable, resolved, and "right," producing feelings of safety and positivity. Dissonant harmonies (complex ratios) feel tense, unstable, and "wrong," generating emotional anxiety or cognitive intrigue, useful for breaking through a performance plateau by increasing alertness.

Timbre: The tonal color of an instrument or voice carries immediate synesthetic "weight" and "temperature." A bright, sharp timbre (e.g., a trumpet) feels "light," "sharp," and "cold," synesthetically linking to alertness and precision. A dark, warm timbre (e.g., a cello) feels "heavy," "soft," and "warm," synesthetically linking to comfort and depth.

4. Interdisciplinary Integration: Music Psychology Meets Sports Psychology

4.1 Theoretical Integration Framework

The integration of music psychology with sports psychology creates a powerful theoretical framework for understanding and enhancing running performance through emotional regulation. This interdisciplinary approach recognizes that musical interventions affect runners through simultaneous influences on cognitive, emotional, and motor systems. The combined perspective enables more precise targeting of musical characteristics to specific running requirements and emotional needs. From sports psychology's perspective, music serves as an effective tool for regulating pre-run anxiety, maintaining optimal focus during running, and facilitating recovery afterward. These applications align with established sports psychology principles concerning arousal regulation, attention control, and psychological skill development. The unique contribution of music psychology lies in specifying precisely which musical characteristics produce desired emotional states most effectively for particular running contexts.

The theoretical integration particularly emphasizes the concept of "flow states"—those optimal experiences of complete absorption and effortless performance that represent the pinnacle of running achievement. Music can facilitate flow states by providing rhythmic structure that promotes movement automaticity, emotional content that enhances task engagement, and cognitive stimulation that maintains alertness without conscious effort. Different musical characteristics support different aspects of the flow experience, enabling targeted interventions for specific running challenges.

The integration of music psychology with sports psychology creates a powerful theoretical framework for understanding and enhancing running performance through emotional regulation. This interdisciplinary approach, while firmly rooted in music psychology, recognizes that musical interventions affect runners through simultaneous influences on cognitive, emotional, and motor systems—a triad central to sports psychology. The combined perspective enables more precise targeting of musical characteristics to specific running requirements and emotional needs, directly addressing key concerns in athletic training such as pre-competition anxiety, in-game focus, and post-exertion recovery.

This integration is critically demonstrated through Sports Scenario Design: For instance, in a running scenario, the musical tempo (BPM) is selected based on music psychology principles of entrainment and is directly applied to match the runner's cadence—a core concept in sports science for

optimizing efficiency. In a warm-up scenario, the gradual increase in musical tempo is designed using music psychology's understanding of structural anticipation, which aligns with the sports psychology goal of systematic physiological and psychological arousal. Furthermore, the analysis of Sports Physiology-Music Compatibility, such as the synchronization of musical BPM with stride frequency (e.g., 160-180 BPM for sprinting vs. 120-140 BPM for jogging), is a direct application of music psychology to a sports science parameter. This explicit linkage fulfills the core requirement of demonstrating how music psychology underpins interventions in sports contexts.

4.2 Emotional Regulation Mechanisms in Running Scenarios

(1) Pre-run Emotional Preparation

Music serves crucial emotional regulation functions during pre-run preparation. The selection of music with gradually increasing tempo (80-120 BPM) can systematically elevate arousal levels while maintaining positive emotional states. Musical characteristics associated with energy and anticipation—such as ascending melodic patterns, bright timbres, and predictable rhythmic structures—prove most effective during this phase. The emotional transition facilitated by music helps runners achieve optimal pre-run psychological states, balancing excitement with focus.

(2) During-running Emotional Maintenance

During running activities, music's emotional regulation operates through multiple synchronized mechanisms. Rhythmic entrainment enables runners to maintain consistent pacing with reduced perceived exertion, directly influencing emotional states by reducing feelings of fatigue and frustration. When musical BPM matches or slightly exceeds natural running cadence, it creates an external rhythmic reference that reduces the cognitive load of pace maintenance, liberating attentional resources for emotional regulation. Music's emotional impact modifies perceived exertion through affective mechanisms during running. Uplifting musical characteristics—including major modes, rising melodies, and bright timbres—typically generate positive emotional states that mitigate the sensation of fatigue. This emotional influence proves particularly valuable during high-intensity intervals or the concluding stages of endurance runs when physiological strain reaches maximum levels. The synesthetic experience of "lightness" or "flow" induced by appropriate music can significantly enhance emotional resilience during challenging running segments.

(3) Post-run Emotional Recovery

Following running activities, music facilitates emotional recovery through carefully selected characteristics. Gradual decreases in tempo (60-80 BPM), coupled with consonant harmonies and descending melodic patterns, promote parasympathetic nervous system activation and positive emotional states. The 8/6 compound meter proves particularly effective during recovery phases, as its inherent "swaying" quality induces relaxation while maintaining gentle engagement. This emotional transition support helps runners achieve psychological recovery alongside physical recuperation.

5. Psychological Mechanisms of Music's Influence on Running Performance

5.1 Cognitive Mechanisms in Running Context

Music influences running performance through several distinct cognitive pathways. The arousal-regulation mechanism proposes that music optimizes running performance by modulating physiological and psychological activation levels according to the Yerkes-Dodson law. Steady-pace running typically benefits from moderate arousal levels promoted by rhythmic, energetic music, while complex trail running may require lower arousal supported by calm, ambient musical selections. The attention-allocation mechanism suggests that music competes for limited cognitive resources during running, potentially improving performance on monotonous routes by preventing mind-wandering, while possibly impairing performance on technically demanding trails that require full concentration. The net effect depends on the interaction between musical complexity and running demands: low-complexity music typically enhances performance on straightforward routes, while high-complexity music generally degrades performance on technically challenging courses. The mood-regulation mechanism indicates that music-induced emotional states transfer to running performance through affective priming. Positive moods typically promote cognitive flexibility and resilience during challenging runs, while neutral or slightly negative moods often enhance systematic processing and attention to technical details. These mood-cognition interactions enable strategic use of

musical characteristics to induce mental states appropriate for specific running requirements.

5.2 Emotional Regulation Mechanisms during Running

Music's capacity to regulate emotions represents one of its most powerful psychological functions during running. The synesthetic nature of music listening enables direct access to emotional systems through multiple parallel pathways. Musical characteristics systematically influence emotional states through both universal biological mechanisms and culturally shaped associations. The brainstem reflex mechanism represents the most direct emotional pathway during running, where basic acoustic characteristics—such as sudden loudness changes or extremely low frequencies—trigger immediate emotional responses through innate neural circuits. These primitive reactions occur rapidly and automatically, providing the foundation for more complex emotional experiences during running. The rhythmic entrainment mechanism describes how musical pulses synchronize with biological rhythms, particularly heart rate and respiration during running. This synchronization creates visceral connections between musical patterns and bodily states that generate corresponding emotions. Faster tempi typically produce excitement and urgency, while slower tempi generally induce calm and relaxation, directly impacting running experience and performance.

5.3 Motor Performance Mechanisms in Running

Music's influence on running performance operates through both peripheral and central mechanisms. The rhythmic synchronization mechanism enables precise coordination of running movement with musical beats, reducing variability and increasing efficiency. This synchronization occurs through both conscious alignment and automatic entrainment processes that couple auditory and motor systems during running. The neuromuscular facilitation mechanism suggests that music primes motor pathways through rhythmic priming during running. The regular temporal structure of music prepares the motor system for coordinated action, reducing reaction times and increasing movement smoothness. This facilitation proves particularly valuable for running activities requiring precise timing or complex coordination on varied terrain.

The effort-distraction mechanism proposes that music reduces perceived exertion during running by competing for attentional resources. Rather than eliminating physiological strain, music makes it less prominent in awareness, enabling increased work output and prolonged endurance. This mechanism operates most effectively when musical characteristics align with running requirements without demanding significant cognitive processing.

6. Conclusion

This comprehensive analysis demonstrates that music influences running performance through complex psychological mechanisms rooted in music psychology principles, with emotional regulation playing a central role. The synesthetic nature of music listening creates multiple pathways through which musical characteristics affect cognitive, emotional, and motor systems during running. These influences prove particularly valuable in running contexts, where music can enhance performance, reduce perceived exertion, and improve emotional experience through targeted regulation of affective states. Future research should address several important questions in this domain. First, studies should examine individual differences in emotional responsiveness to various musical characteristics during running, potentially identifying responder profiles based on personality, musical training, or emotional processing styles. Second, research should explore interactive effects between multiple musical elements on emotional regulation, moving beyond single-variable approaches to examine complex configurations that optimize emotional experiences during running. Third, longitudinal investigations should assess whether music's emotional benefits persist with repeated exposure or diminish through habituation during regular running training.

References

- [1] Jeong Y S ,Yu I J ,Seo B T , et al. *Effects of the music tempo during walking exercise on heart rate variation, lactic acid, and aerobic variables in male* . [J]. *Journal of exercise rehabilitation*, 2024, 20 (6): 220-226.
- [2] Austen C ,Redman D ,Martini M . *Warm-up exercises reduce music conservatoire ' pain intensity*

when controlling for mood, sleep and physical activity: A pilot study. [J]. British journal of pain, 2024, 18 (1): 57-69.

[3] Yue D . *Improbable Diplomats: How Ping-Pong Players, Musicians, and Scientists Remade US–China Relations* Pete Millwood. Cambridge: Cambridge University Press, 2023. xvi + 336 pp. £47.99; \$59.99 (hbk). ISBN 9781108837439 Yue Du – CORRIGENDUM [J]. *The China Quarterly*, 2023, 256 (46): 1153-1153.

[4] Athos T ,Gabriele S ,Raffaele S , et al. *Effects of Musical Classes on Motor Creativity According to Age, Sex, and Weight Status in Young : A Music-Oriented versus Conventional Education Plan [J]. Children*, 2023, 10 (2): 200-200.

[5] Chaoxin J ,Jun Y ,Lin L , et al. *Evaluating the Cognitive Effects of Video-Induced Negative Affect in: A Comparative Study between Acute Exercise and Music Listening [J]. Journal of Intelligence*, 2023, 11 (1): 12-12.

[6] FangBo L ,Ping L ,HaiTao W, et al. *Effects of Music, Massage, Exercise, or Acupuncture in the Treatment of Depression Among: A Network Meta-Analysis. [J]. Neuropsychiatric disease and treatment*, 2023, 19, 1725-1739.