Bala V, J Brain Neuros Res 2026, 10: 038
DOI: 10.24966/BNR-HSOA/100038

HSOA Journal of
Brain & Neuroscience Research

Review Article

Music, Frequency and Cognition: A Systematic Synthesis of Tempo, Lyrics and Vibroacoustic Effects

Vaidya Bala*

Medical Co-Director Public and Population Health, Senior Staff Specialist in Brain Injury Rehabilitation, The Wollongong Hospital, Australia

Abstract

Different musical features (tempo, mode, lyrics, familiarity) and vibration-based interventions (binaural beats, vibroacoustic therapy, whole-body vibration) reliably produce short-term modulation of arousal, attention, and mood, whereas effects on memory and higher executive functions are mixed and often small. This consolidated systematic synthesis integrates recent reviews and empirical studies to (a) summarise mechanistic pathways (arousal modulation, emotional priming, neural entrainment, somatosensory input), (b) compare cognitive outcomes across stimulus classes, and (c) identify methodological gaps and priorities for future research. Across studies, tempo, lyrics, and familiarity show the most consistent behavioural effects; frequency-based auditory stimulation and vibroacoustic/WBV reliably alter physiological and neural markers but yield heterogeneous behavioural gains. We recommend standardised stimulus reporting, preregistration, active/placebo controls, and multimodal biomarkers to clarify dose–response relationships and enable clinical translation.

Introduction

Music and low-frequency vibrations influence cognition through interacting mechanisms: modulation of autonomic arousal, affective priming, neural entrainment of oscillatory activity, and multisensory somatosensory input [1-5] . Specific musical features—tempo, mode (major/minor), presence of lyrics, and familiarity-shape emotional and attentional states that in turn affect processing speed, sustained attention, and verbal working memory [1,5]. Frequency-targeted auditory paradigms (e.g., binaural beats) aim to entrain EEG bands, while vibroacoustic therapy and whole body vibration (WBV) add tactile and vestibular components that can modulate autonomic and neurochemical states relevant to cognition [2,3,6]. This consolidated article synthesises recent systematic reviews and empirical syntheses to provide an integrated account of effects, mechanisms, moderators, and methodological recommendations.

***Corresponding author:** Vaidya Bala, Medical Co-Director Public and Population Health, Senior Staff Specialist in Brain Injury Rehabilitation, The Wollongong Hospital, Australia, E-mail: vaidya.balasubramaniam@health.nsw.gov.au

Citation: Bala V (2026) Music, Frequency and Cognition: A Systematic Synthesis of Tempo, Lyrics and Vibroacoustic Effects. J Brain Neuros Res, 10: 038.

Received: January 20, 2026; **Accepted:** January 27, 2026; **Published:** February 03, 2026

Methods and Analysis

Scope and selection

We combined two recent syntheses that prioritized systematic reviews and highquality empirical studies addressing: (a) music feature manipulations (tempo, mode, lyrics, familiarity), (b) frequencyspecific auditory stimulation (including binaural beats), and (c) vibroacoustic and WBV interventions [2,3,5].

Data extraction

From each source, we extracted population characteristics, stimulus parameters (tempo, frequency, amplitude, waveform, duration), cognitive endpoints (attention, memory, executive function, processing speed, mood), neurophysiological measures (EEG, fNIRS), and methodological quality indicators (sample size, blinding, control conditions, preregistration).

Synthesis approach

Because of heterogeneity in stimuli and outcomes, findings were synthesised thematically rather than meta-analytically. We organised results by stimulus class (music features; frequency-based auditory stimulation; vibroacoustic/WBV), then identified common mechanisms and moderators, and finally distilled practical and research recommendations [4,5,7].

Results and Synthesis

Music Features

Tempo and arousal

Faster tempo reliably increase physiological arousal and response speed, improving performance on simple, speeded tasks but sometimes impairing accuracy on complex, deliberative tasks; slower tempo reduces arousal and can benefit precision and accuracy [1,8].

Mode and emotional valence

Major/minor mode and tonal features bias affective state and produce mood-congruent effects on memory encoding, decision bias, and creative thinking; these emotional priming effects mediate some cognitive changes attributed to music [4,8].

Lyrics versus instrumental

Music with lyrics competes for phonological and semantic processing resources, reliably impairing verbal working memory, reading comprehension, and verbal recall—especially when lyrics are in the listener's native language or when tasks are verbally demanding [2,9].

Familiarity and preference

Familiar or preferred music tends to stabilise mood, reduce mind-wandering, and sometimes improve sustained attention and task persistence; benefits appear mediated by reduced intrusive thoughts and increased motivation, though effects vary by task and individual differences [4,10].

Frequency-Based Auditory Stimulation and Neural Entrainment

Binaural beats and narrowband stimulation

Binaural beat protocols and narrowband stimuli can shift EEG power and phase within targeted frequency bands and elicit transient subjective changes in arousal and attention. Reviews report more consistent physiological entrainment than behavioural gains; behavioural effects (e.g., modest improvements in sustained attention or mood) are often small and sensitive to expectancy and placebo controls [2,11,12].

Vibroacoustic Stimulation and WholeBody Vibration

Vibroacoustic therapy

Low-frequency sound delivered through surfaces or chairs has been associated with reductions in physiological stress markers and improvements in sustained attention and working memory in some clinical and healthy samples. Mechanistically, vibroacoustic stimulation likely combines auditory entrainment with somatosensory input to modulate arousal and multisensory integration; however, reporting of parameters (frequency, amplitude, waveform) is often inconsistent [3,11].

Wholebody vibration (WBV)

WBV studies show mixed cognitive outcomes. Animal and small human trials suggest neuroplastic and neurochemical changes that could support cognition, and some human trials report modest executive or processingspeed gains-particularly in older or clinical populations-but effects depend strongly on frequency, amplitude, posture, and exposure duration, and replication is limited [6,13,14].

Moderators and Methodological Issues

Across stimulus classes, outcomes are moderated by task demands (verbal vs. nonverbal), baseline arousal and personality, cultural background, and expectancy/placebo effects [2,5]. Common methodological limitations include small samples, short follow-up, heterogeneous and underreported stimulus parameters, inconsistent blinding, and variable outcome measures-factors that hinder cumulative inference and meta-analysis [3,14].

Practical Recommendations

- **Task matching:** Use fast tempo for simple speeded tasks; avoid music with lyrics during verbal learning or reading; prefer familiar instrumental music for repetitive, lowengagement tasks to reduce mindwandering [1,2,10].
- **Clinical application:** Apply vibroacoustic interventions under clinical oversight with careful parameter control for stress reduction and attention support [3].
- **Research design:** Preregister protocols, include active/placebo controls, report detailed acoustic and vibrational parameters (tempo, frequency, amplitude, waveform, delivery method), and combine behavioural endpoints with multimodal neurophysiological markers (EEG, fNIRS) to clarify mechanisms and dose–response relationships [5,14].

Conclusion

Music and vibration-based stimulation reliably modulate arousal, attention, and mood in the short term. The most consistent behavioural effects arise from tempo, lyrics, and familiarity manipulations, while frequency-based auditory stimulation and vibroacoustic/WBV reliably alter physiological and neural markers but produce heterogeneous behavioural benefits. Translating these findings into robust cognitive interventions requires larger, preregistered randomised trials with standardised stimulus reporting and multimodal mechanistic measures [2,3,11].

Limitations of this Paper

- **Scope and source dependence:** This consolidation synthesizes two recent syntheses and their cited literature; it does not include an independent, exhaustive search of all primary studies beyond those sources, which may omit emerging or contradictory evidence [14].
- **Heterogeneity precluded metaanalysis:** Diverse stimulus parameters and outcome measures prevented quantitative pooling; effect magnitudes therefore remain approximate and contextdependent [5].
- **Publication and reporting bias:** Many included reviews note small sample sizes and selective reporting of positive outcomes, which may inflate apparent efficacy for some interventions [3].
- **Generalisability:** Findings vary across populations (healthy young adults, older adults, clinical groups); recommendations should be adapted to specific populations and task demands [6].
- **Parameter underreporting:** Inconsistent reporting of acoustic and vibrational parameters limits reproducibility and dose–response inference [11].

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