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Neuroaesthetic Frequency Tuning for Neurodivergent Populations: A Network-Informed Theory of Music for Emotional Memory and Cognitive Regulation

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Abstract

Neuroaesthetic frequency tuning posits that deliberate selection of musical parameters can modulate large-scale neural systems to support emotional memory retrieval and cognitive regulation in neurodivergent populations. Drawing on contemporary evidence from network neuroscience, cognitive musicology, and affective science, the article synthesizes how rhythmic, harmonic, and lyrical structures align with Default Mode (DM), fronto-parietal control, salience, motor, and limbic systems, and how these alignments can be targeted to balance internally oriented mentation with task engagement. The theory further integrates autonomic and cellular mechanisms, describing how tempo and spectral energy shift arousal and heart rate variability, and how astrocytic ensembles contribute to consolidation and reactivation of emotionally salient memory traces. The argument advances specific mappings: structured baroque and film-score textures to stabilize attention and downregulate DM dominance; steady rhythmic entrainment to engage motor timing circuits and improve executive timing; improvisational forms to stimulate creative recombination through salience-mediated switching; and autobiographically meaningful lyricism to unlock autobiographical memory via limbic pathways. A translational schema is proposed that links assessment of attentional profile, sensory preference, and autobiographical salience to a dosing rubric for frequency, tempo, predictability, and lyrical density, with measurement through behavior, EEG, and heart rate variability. The model yields testable predictions regarding responder profiles, dose–response curves, and network-specific outcomes in attention and emotional regulation. The article concludes that neuroaesthetic frequency tuning offers a theoretically coherent, mechanistically plausible, and ethically tractable basis for precision music intervention in education and clinical practice for neurodivergent communities. Future research should refine protocols and validate outcomes across settings.

Keywords: neuroaesthetics, neurodivergence, frequency, memory, astrocytes

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Introduction

Music occupies a distinctive position within neurocognitive research because it recruits distributed brain systems implicated in attention, memory, emotion, and autonomic regulation, yet translational frameworks for tailoring musical parameters to specific neural targets in neurodivergent populations remain underdeveloped (Belfi & K. E. Janata, 2021; Luo & Zhang, 2025; Woods et al., 2024). The present study advances a social-science-oriented theory of neuroaesthetic frequency tuning that defines how spectral content, tempo, rhythmic regularity, harmonic predictability, and lyrical salience can be selected to modulate large-scale brain networks and psychophysiological states relevant to autism and attention-deficit/hyperactivity disorder. This theoretical contribution is motivated by convergent evidence that music can unlock autobiographical recall, alter DM and fronto-parietal dynamics, and reshape autonomic balance, all of which bear directly on educational participation and self-regulation for neurodivergent learners (Belfi & K. E. Janata, 2021; Kaiser et al., 2023; Luo & Zhang, 2025).

Within this framework, frequency tuning denotes the principled selection and dosing of musical parameters to engage target networks and outcomes; network modulation denotes measurable shifts in large-scale systems such as the DM, salience, motor timing, limbic, and executive control networks during or following exposure; and regulation outcomes denote behavioral, cognitive, and physiological indices including sustained attention, emotion regulation, autobiographical memory access, and heart-rate variability (Arnold et al., 2024; Woods et al., 2024). The scope is centered on neurodivergent populations for two reasons: first, randomized and mechanistic studies indicate that music can improve social communication and reorganize connectivity in autism; second, parameterized music can sustain attention in individuals with greater attentional difficulty, a core concern in ADHD (Sharda et al., 2018; Woods et al., 2024).

The problem addressed is the absence of a falsifiable, network-informed account that links specific musical parameters to hypothesized mechanisms and testable responder profiles rather than treating music as a monolithic stimulus. Recent findings that emotionally salient learning engages astrocytic ensembles that stabilize long-term memory further underscore the need to consider cellular as well as systems-level mechanisms when theorizing music-evoked autobiographical memory in neurodivergence (Dewa et al., 2025; Kaiser et al., 2023). Building on these literatures, the article contributes: a structured definition of frequency tuning and network modulation; a mapping from musical parameters to hypothesized network targets and regulation outcomes in autism and ADHD; and a set of testable propositions that connect parameter "doses" to within-person changes in behavior, EEG-derived network balance, and heart-rate variability. Finally, the significance is twofold: theoretically, the model integrates affective neuroscience, network dynamics, and psychophysiology into a coherent account of how aesthetic structure can shape cognition; practically, it motivates precision playlisting and closed-loop adaptation that are ethically tractable and culturally responsive in schools and clinics serving neurodivergent communities (Luo & Zhang, 2025; Matziorinis et al., 2022; Woods et al., 2024).

Literature Review

Research on music-evoked autobiographical memory has matured into a coherent literature demonstrating that songs reliably cue vivid, self-relevant recollections across the lifespan and into clinical contexts (Table 1). Large-sample and systematic reviews converge on high base rates of recall and rich phenomenology, while also noting unresolved questions about which musical attributes best predict memory quality and retrieval efficiency (e.g., tempo, timbre, lyrical salience) (Kaiser et al., 2023; Nawaz et al., 2025). Recent work extends these findings to healthy aging, documenting qualitative characteristics of music-evoked memories and their affective tones, which supports the use of personalized music as a probe of identity-relevant memory traces (O'Shea et al., 2025). Parallel lines of inquiry in neurodivergent populations are smaller but suggest that music can facilitate autobiographical access and social communication through engagement of reward and limbic circuits, consistent with observations from autism intervention trials and observational designs reviewed elsewhere (Sharda et al., 2018; Kaiser et al., 2023). At the theoretical level, these results align with predictive-processing accounts in which stylistic regularities and emotionally salient cues reduce retrieval costs by furnishing strong priors and affective tagging. Yet the field still lacks parameterized tests that manipulate musical structure while measuring autobiographical retrieval with preregistered outcomes, a gap that motivates the precision "tuning" proposals advanced in recent frameworks. In short, evidence supports the potency of music as a cue for autobiographical memory, but the determinants of which musical features optimize recall for whom remain underspecified (Kaiser et al., 2023; Nawaz et al., 2025).

Table 1. Domains relevant to neuroaesthetic frequency tuning

Theme	Representative finding	Population/ design	Key measures	Implication for tuning	Citation
Music-evoked autobiographical memory (MEAM)	Songs cue vivid, self-relevant memories with rich phenomenology; determinants include lyrical salience and familiarity	Reviews; experimental and survey studies in adults and older adults	Memory specificity, latency, affective tone	Use autobiographically meaningful, lyric-forward tracks when recall is the target	(Kaiser et al., 2023)
MEAM in aging and clinical care	Personalized music facilitates access to identity-relevant memories in aging contexts	Observational and interview studies in healthy aging	Qualitative MEAM coding frameworks	Curate "memory songs" tied to lived experience for retrieval tasks	(O'Shea et al., 2025)
Autism trials and connectivity	Improvisational music therapy improves social communication and reorganizes auditory–	RCT in autistic children	Behavioral communication scales; resting-	Pair moderate novelty and interactive rhythm to scaffold	(Sharda et al., 2018)

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	motor–limbic connectivity		state and task connectivity	engagement	
Attention support via modulation	Amplitude-modulated music selectively sustains attention in listeners with attentional difficulties	Human behavioral experiments with subgroup analyses	Sustained attention tasks; performance variability	Select mid-tempo, predictably modulated textures for ADHD focus blocks	(Woods et al., 2024)
DMN dynamics during music	Musical tempo and structure bias Default Mode spatiotemporal patterns and transitions with control networks	Neuroimaging analyses during music listening	Network transitions; DMN spatiotemporal metrics	Adjust tempo to nudge DMN–executive balance for ideation vs focus	(Watters et al., 2024)
Entrainment and cognition	Cortical synchronization tracks beat and spectral features; effects depend on tempo, familiarity, expertise	EEG/MEG entrainment studies	Phase locking, spectral flux, beat tracking	Align beat frequency with attentional goals; avoid overload in sensitive profiles	(Doelling & Poeppel, 2015; Wollman et al., 2020; Tichko et al., 2022)
Autonomic regulation (HRV)	Slower, consonant music often increases vagally mediated HRV, though heterogeneity persists	Scoping and systematic reviews; cohort studies	HRV (RMSSD, HF power), LF/HF	Use slow, consonant pieces before/after demand to support co-regulation	(Arnold et al., 2024; van der Wal-Huisman et al., 2024)
Reward and preference	Preference and familiarity amplify engagement and adherence, interacting with structural parameters	Experimental studies with preference controls	Reward indices, adherence, performance gains	Match cultural and autobiographical context while meeting parameter targets	(Zaatar et al., 2024)
Cellular mechanisms of memory	Astrocytic ensembles stabilize emotional memories over days and re-engage at recall	Animal models; cellular imaging	Astrocyte tagging and reactivation	Leverage emotionally salient stimuli when durable memory reconsolidation is desired	(Dewa et al., 2025)
Integrative framework (uploaded manuscript)	Frequency and structure can be tuned to recruit limbic, fronto-parietal, salience, motor, and DMN systems for regulation and recall	Theoretical synthesis	Cross-domain mapping and proposed dosing	Use parameterized playlists with measurement-guided adaptation in neurodivergence	Hutson (2025)

Converging evidence also links music to large-scale brain dynamics involving the DM Network and task-positive systems. A 2025 scoping review organizes reports of DMN engagement during listening, imagery, and improvisation, indicating that musical context can either potentiate internally oriented mentation or, when structured predictably, facilitate transitions toward executive and dorsal attention networks (Hodges, 2025). Online Experimental and quasi-experimental studies of improvisation further implicate coordinated activity across medial prefrontal, posterior cingulate, dorsolateral prefrontal, premotor, and cerebellar regions, consistent with dynamic coupling between DMN and executive control during creative musical behavior (Barrett et al., 2025). Time-resolved analyses of quasi-periodic patterns during music exposure suggest that musical tempo and structure can bias the expression of intrinsic network states, offering a mechanistic bridge between stimulus statistics and network-level fluctuations (Watters et al., 2024). From an applied perspective, amplitude-modulated music has been shown to sustain attention more effectively for listeners with higher attentional difficulties, implying that specific modulation rates interact with individual neurocognitive profiles, a result directly relevant to ADHD (Woods et al., 2024). These findings place music within the broader literature on network competition and state regulation, where targeted acoustic parameters might down-bias DMN dominance during task demands or harness DMN–executive coactivation for ideation. Nevertheless, direct demonstrations that particular musical parameters causally shift DMN-to-task-positive balance during performance, especially in neurodivergent cohorts, remain rare.

A complementary strand addresses autonomic regulation and neural entrainment. Meta-analytic and scoping evidence indicates that music modulates heart-rate variability, with slower, harmonically stable selections tending to increase vagally mediated HRV, although study heterogeneity and risk of bias temper strong conclusions (Arnold et al., 2024; van der Wal-Huisman et al., 2024; Pepplinkhuizen et al., 2025). Entrainment studies show that cortical activity synchronizes with rhythmic and spectral features of music in frequency-specific ways, and that synchronization is sensitive to tempo, spectral flux, beat salience, familiarity, and expertise, thereby providing a plausible route from stimulus parameters to attentional control (Doelling & Poeppel, 2015; Tichko et al., 2022; Wollman et al., 2020). Classic demonstrations that the brain can generate a perceived pulse even when it is not explicitly present underscore the internal dynamics through which music can scaffold timing, with implications for motor and

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attentional regulation relevant to ADHD and autism (Tal et al., 2017). Despite these advances, key gaps persist. Responder heterogeneity is substantial, with preference, prior musical experience, sensory sensitivities, and baseline arousal shaping outcomes; however, most studies are underpowered to model these moderators. Mechanistic specificity is also incomplete, since many reports rely on self-report or global behavioral indices without concurrent network-level measures, and few studies jointly quantify EEG or fMRI connectivity with HRV and behavior under parameterized musical manipulations in neurodivergent samples. Addressing these gaps will require preregistered, within-person, crossover designs that estimate individual dose–response curves for tempo, modulation rate, harmonic predictability, and lyrical density while indexing DMN–executive balance and autonomic state in real time.

Theoretical Framework

The proposed theoretical framework treats music as a structured stimulus that perturbs perception and cognition through predictive processing, thereby shaping attentional control and large-scale network dynamics **(Table 2)**. Under this account, rhythm, harmony, timbre, and lyrical salience function as priors that tune precision weighting in cortical hierarchies, biasing competition between the DM system and task-positive control circuits toward states conducive to regulation or ideation. Reward-based engagement is not ancillary but constitutive: dopaminergic responses to expectation, surprise, and resolution stabilize learning signals that couple affect to memory traces and sustain effortful attention during cognitively demanding tasks. The framework maps parameters to networks with specificity: steady rhythmic entrainment recruits motor, basal ganglia, and cerebellar timing systems; predictable harmonic structure engages fronto-parietal executive resources; novelty and syncopation invoke salience-driven switching; and emotionally salient lyrics preferentially recruit limbic pathways implicated in autobiographical recall. Autonomic modulation serves as an integrative conduit linking bodily state to network expression, with tempo and spectral energy shifting vagal tone and arousal in ways that facilitate or impede executive stability. At the cellular level, hypothesized astrocytic participation in consolidation and reactivation provides a substrate for durable emotional memory, suggesting that music-evoked arousal and valence may gate glial–neuronal ensembles that later re-engage during recall. This multilevel model renders frequency tuning a tractable construct: principled selection of tempo, spectral density, harmonic predictability, and lyrical content aims to produce measurable shifts in network balance, autonomic indices, and memory access. As articulated in the source manuscript motivating this synthesis, music is treated as a biologically potent network modulator whose effects can be parameterized for precision intervention in neurodivergent contexts.

Table 2. Parameter-to-network map with predicted outcomes, autonomic effects, exemplar stimuli, measurement plan, and falsifiable hypotheses

Musical parameter	Primary neural targets	Predicted cognitive and affective outcomes	Autonomic effects	Exemplar stimuli	Core measures and biomarkers	Falsifiable hypothesis (summary)
Tempo (slow, mid, fast)	DMN increases with slow; frontoparietal control increases with mid; dorsal attention increases with fast-to-mid; salience increases with transition rates	Slow promotes reflection; mid supports sustained attention and working memory; fast energizes vigilance with distraction risk	Slow increases HRV via vagal tone; mid balances arousal; fast decreases HRV via sympathetic activation	60–80 BPM strings; 90–110 BPM lo-fi beats; 120–130 BPM rhythmic pop	EEG frontal alpha and theta; midline theta suppression; reaction time variability; HRV RMSSD and HF power	Attention follows an inverted U across tempo with phenotype-specific optima, with ADHD showing a mid-tempo advantage over slow and fast
Rhythmic regularity (steady vs. syncopated)	Basal ganglia and cerebellum for steady; salience and premotor for syncopation	Steady improves timing and sustained focus; moderate syncopation enhances idea fluency with minimal accuracy cost	Steady stabilizes HRV; syncopation induces brief arousal spikes	Metronomic lo-fi; marching snare; light jazz funk syncopation	EEG phase locking to beat; sensorimotor beta; drift–diffusion parameters for sustained attention	Steady rhythms reduce reaction time variability; moderate syncopation increases divergent thinking without degrading task accuracy
Harmonic predictability (consonant vs. novel)	Frontoparietal control for predictability; salience network for unexpected change; reward	Predictable harmony improves goal maintenance and working memory; controlled	Predictable harmony increases HRV via reduced uncertainty; novelty produces	Consonant I–IV–V progressions; film-score ostinati; sparse modal shifts	EEG frontal midline theta; pupillometry for surprise; n-back and task switching	Predictable harmony yields higher accuracy on executive tasks; controlled novelty reduces switch costs relative to fully

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	network at resolution	novelty facilitates set shifting	transient sympathetic spikes with reward offset			predictable or highly chaotic sequences
Spectral energy and brightness	Locus coeruleus–noradrenergic arousal, salience network, auditory gain control	Low-to-moderate density supports focus; high density risks overload in sensory-sensitive listeners	Higher spectral energy decreases HRV; lower spectral energy increases HRV, context dependent	Warm strings or piano pads versus bright brass or synth leads	Spectral centroid and flux versus performance; HRV LF/HF ratio; sensory overload scales	Sensory-sensitive phenotypes show steeper performance declines as brightness increases compared to non-sensitive peers
Lyric density and autobiographical salience	Limbic system including amygdala and hippocampus with DMN coupling; ventral striatal reward	Lyric-forward, personally meaningful tracks enhance cue-dependent episodic recall and bonding; potential interference with concurrent complex cognition	Emotionally salient lyrics raise arousal; recovery depends on tempo and harmony context	Personal "memory songs"; narrative soul or folk ballads	Music-evoked autobiographical memory interviews with latency and specificity coding; skin conductance and pupil response; EEG late positive potential	Lyric-salient selections improve autobiographical recall but reduce concurrent working-memory performance relative to instrumental controls
Improvisationality and novelty	Coupling between DMN and executive control; salience switching; premotor planning	Moderate novelty increases creativity and idea fluency; high novelty degrades sustained attention	Moderate novelty balances arousal; high novelty produces sympathetic surges	Light jazz improvisation; ambient with generative variation	Time-resolved functional connectivity and phase lag indices; creative fluency tasks	Creativity exhibits an inverted U with novelty; sustained attention declines at very low and very high novelty levels
Dose and scheduling (session length and frequency)	Network priming and fatigue across sessions	Short, frequent sessions optimize retention; long sessions risk diminishing returns	HRV recovery between sessions predicts next-session gain	Two 15-minute daily blocks versus one 30-minute block	Individual growth-curve slopes; HRV recovery as mediator	Split dosing yields greater cumulative gains; recovery mediates dose–response effects

From this framework follow research questions and hypotheses that are explicitly network-targeted and dose-sensitive. First, exposure to structured, mid-tempo harmonic textures is hypothesized to reduce DM dominance and increase fronto-parietal engagement, producing gains in sustained attention and working memory in ADHD; conversely, improvisational or moderately unpredictable textures should enhance idea fluency and associative breadth through salience-mediated coupling of DMand control systems. Second, lyric density and autobiographical salience are predicted to amplify limbic recruitment and improve cue-dependent episodic recall, particularly in autistic individuals who exhibit strong sensory-anchored memory profiles. Third, dose–response relations are expected for tempo, modulation rate, and spectral energy: inverted-U functions should characterize attentional outcomes as a function of arousal, with individual optima varying by baseline vigilance, sensory sensitivity, and preference. Fourth, responder phenotypes are proposed a priori: executive-unstable yet under-aroused individuals should benefit from moderately fast, predictable rhythms with low lyrical density; executive-overloaded or anxious individuals should benefit from slower, harmonically consonant textures with gentle spectral profiles; memory-retrieval goals should privilege autobiographically meaningful, lyric-forward selections paired with moderate arousal. Fifth, the framework predicts cross-level interactions in which autonomic shifts mediate part of the music-to-attention pathway, while reward responses moderate adherence and cumulative gains. These propositions convert frequency tuning from a descriptive metaphor into falsifiable claims about how parameter profiles map to network states and regulation outcomes in distinct neurodivergent subgroups, consistent with the translational orientation of the underlying source.

The measures and analysis plan operationalize these hypotheses with convergent behavioral, physiological, and neural indices embedded in within-person designs. Primary outcomes include continuous measures of attention (e.g., drift-diffusion parameters from sustained attention tasks), affect regulation (state anxiety, affect grids, and recovery slopes following standardized stressors), and autobiographical recall (latency, specificity, and

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phenomenological richness coded from structured MEAM interviews). Biomarkers include EEG-derived network indices capturing DM and executive balance via midline theta, frontal alpha, and beta-power asymmetries; phase-locking to musical pulse as an entrainment metric; and heart-rate variability parameters indexing vagal regulation at rest and during tasks. Study designs favor randomized, counterbalanced crossover and single-case multiple-baseline protocols to estimate individualized dose–response curves for tempo, spectral energy, predictability, and lyrical density. Multilevel models account for repeated measures nested within persons and allow cross-level interactions between parameter doses and phenotype covariates; time-series models (e.g., state-space or vector autoregression) capture lagged coupling between autonomic and neural indices; and mediation analyses test whether autonomic change partially transmits music's effects on attention or recall. Preference and familiarity are measured and included as moderators to separate arousal-driven benefits from structural specificity, while manipulation checks ensure parameter fidelity in delivered stimuli. Power analyses focus on within-person effect sizes and reliability of individual slopes, with replication plans across sites to test generalizability. This integrated plan aligns measurement with mechanism, enabling rigorous tests of the network-informed, frequency-tuning account articulated in the source document

Implications for Practice and Policy

The present synthesis interprets neuroaesthetic frequency tuning as a mechanistically plausible account in which musical parameters shape predictive processing, attentional control, and the coupling of limbic, fronto-parietal, salience, motor, and DM systems. Evidence that musical tempo and structure bias intrinsic network dynamics, including DM spatiotemporal patterns, lends support to network-specific mechanisms rather than a purely nonspecific arousal effect, particularly when creative states depend on dynamic DM–executive coupling under musical constraints (Watters et al., 2024). Findings that amplitude-modulated music at targeted rates selectively sustains attention for individuals with attentional difficulties further strengthen parameter specificity claims and align with a precision-tuning perspective that emphasizes dose and individual profile rather than genre labels alone (Woods et al., 2024). Nature At the same time, systematic reviews of music and vagally mediated heart-rate variability indicate that slower, harmonically stable music can increase parasympathetic tone, which clarifies how arousal regulation acts as a pathway that may mediate some performance effects across diverse listeners (Flater et al., 2025). Recent randomized trials in autism show gains in social communication following music therapy, consistent with a mechanism in which auditory–motor–limbic engagement scaffolds communicative behavior, while protocols now embed neuroimaging and biological outcomes that will permit adjudication among network, arousal, and reward accounts (Jaschke et al., 2024; Zhou et al., 2025). Entrainment studies that manipulate beat frequencies and quantify neural synchronization also support a specificity claim by demonstrating tempo-dependent changes in cortical coupling that correlate with cognition, yet these effects coexist with preference-driven reward responses that likely amplify adherence and learning signals (Aparicio-Terrés et al., 2025; Zaatar et al., 2024). Boundary conditions therefore emerge: parameter specificity appears strongest when musical features are matched to individual attentional needs, but arousal and preference remain potent moderators. Mechanistic plausibility extends to the cellular level given evidence that astrocytic ensembles stabilize emotional memories across days, which raises testable predictions about how emotionally salient music could gate glial–neuronal engrams that later support autobiographical recall in neurodivergent profiles (Dewa et al., 2025).

Implications for practice and policy follow from a synthesis that treats music as a configurable stimulus rather than a monolithic treatment. Precision playlisting becomes a design problem: for sustained classroom attention in ADHD, mid-tempo, predictably harmonic textures with modest spectral density and early amplitude modulation can be trialed first, whereas sessions oriented to ideation may employ moderate syncopation or improvisational variability to encourage DM–salience switching without saturating executive resources (Woods et al., 2024; Watters et al., 2024). Co-regulation protocols for caregivers and clinicians can leverage slower, consonant selections to elevate heart-rate variability before or after cognitively demanding tasks, with session timing informed by HRV recovery profiles to avoid sympathetic stacking and reduce behavioral volatility (Flater et al., 2025). Culturally responsive personalization requires curating autobiographically meaningful tracks that respect identity, language, and community norms while still meeting parameter targets for tempo, predictability, and spectral energy; this approach reconciles the specificity of acoustic features with the motivational force of preference and cultural familiarity (Zaatar et al., 2024). For clinical and educational deployments that integrate wearables or neurofeedback, data stewardship must foreground consent, minimal collection, strict role-based access, and short retention windows, since biometric adaptation pipelines may capture sensitive physiological signatures alongside behavioral performance. Finally, emerging autism trials that include neuroimaging and biological readouts should be prioritized in policy guidance and funding decisions because they promise to identify responder phenotypes and mechanism-linked outcomes that justify adoption beyond pilot contexts (Jaschke et al., 2024; Zhou et al., 2025).

The limitations of the current evidence base mandate caution in interpretation and scope. Generalizability is constrained by small samples, short interventions, and convenience recruitment, which limit inferences about heterogeneous neurodivergent populations and real-world settings such as noisy classrooms or overstimulating clinics (Zhou et al., 2025). Measurement constraints are salient: many studies report behavioral outcomes without concurrent network-level indices, and HRV methods often vary in sensors, preprocessing, and spectral bands, which complicates meta-analytic synthesis and mechanistic attribution (Flater et al., 2025). Glial-level inference remains indirect in humans; although astrocytic ensembles stabilize emotional memories in animal models, translational bridges to human music-evoked memory require creative approaches such as multimodal imaging or peripheral molecular proxies before any clinical claims are warranted (Dewa et al., 2025). Preference confounds are persistent given that reward engagement and familiarity can enhance performance independently of structural parameters, so future trials should include preference-matched control tracks to isolate feature specificity (Aparicio-Terrés et al., 2025). Finally, differential DM engagement during music listening varies with expertise and task context, which implies that parameter prescriptions may need to be stratified by musical background as well as diagnosis to avoid overfitting protocols to narrow cohorts (Dai et al., 2025). PMC Taken together, these limitations underscore a research agenda focused on preregistered, within-person, crossover designs that

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estimate individual dose–response functions for tempo, modulation rate, predictability, spectral density, and lyrical salience while jointly modeling behavior, EEG or fMRI connectivity, and autonomic state.

Conclusion

This treatment argues for neuroaesthetic frequency tuning as a network-informed theory that links parameterized musical features to measurable shifts in attention, affect regulation, and autobiographical memory through coordinated engagement of limbic, fronto-parietal, salience, motor, and DM systems; the contribution lies in rendering music a configurable stimulus with testable mappings from tempo, rhythmic regularity, harmonic predictability, spectral energy, and lyrical salience to specific neural and autonomic targets, and in specifying how these mappings may differ across neurodivergent responder profiles. A roadmap for cumulative evidence begins with preregistered, within-person crossover trials that estimate individualized dose–response functions while collecting convergent behavioral, physiological, and neural indices, followed by multi-site replications that stratify by diagnosis, sensory sensitivity, and musical background, and culminating in adaptive, closed-loop protocols that adjust parameters in real time using predefined rules anchored in reliability-checked biomarkers. Infrastructure for accumulation should include standardized stimulus libraries with parametric control, transparent preprocessing pipelines for EEG and heart-rate variability, common task batteries for attention and memory outcomes, and open materials, code, and data to enable independent reanalysis and cross-study synthesis. Clear criteria for falsification require that, under parameterized manipulations, network-level measures fail to change in theoretically predicted directions, dose–response curves collapse to flat or monotonic preference effects, autonomic mediation does not account for putative cognitive benefits, and predictive models using musical features offer no incremental validity over baseline arousal or preference indices when forecasting individual outcomes. Replication should demand prospective, adequately powered, multi-lab studies that preregister hypotheses and analysis plans, reproduce parameter–outcome functions with overlapping confidence intervals, and demonstrate transportability across settings, devices, and cultural repertoires. Together these standards transform a promising synthesis into a cumulative, self-correcting research program in which theoretical specificity, measurement rigor, and open science converge to validate or revise claims about how musical structure can be tuned to support regulation and memory in neurodivergent communities.

Data Availability

Data available upon request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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References

1. Aparicio-Terrés, R., Camarena, M., & Ríos-López, P. (2025). *The strength of neural entrainment to electronic music is related to the tempo of stimulation and cognitive performance*. *Frontiers in Human Neuroscience, 19*, 1574836.
2. Arnold, C. A., Millard, S. K., & Dudeney, J. (2024). *The psychophysiology of music-based interventions and the experience of pain: A scoping review*. *Psychophysiology, 61*(10), e14760. https://doi.org/10.1111/psyp.14760
3. Barrett, K. C., et al. (2025). *Children engage neural reward structures for creative musical improvisation*. *Scientific Reports, 15*, 95619. https://doi.org/10.1038/s41598-025-95619-1
4. Belfi, A. M., & Janata, K. E. (2021). *Music and autobiographical memory*. *Progress in Brain Research, 262*, 1–25. https://doi.org/10.1177/20592043211047123
5. Dai, R., Li, Y., & Zhang, X. (2025). *Differences in dynamic functional connectivity between musicians and non-musicians during music listening*. *Frontiers in Neuroscience, 19*, 1508070.
6. Dewa, K. I., Anzai, M., Adachi, K., Sato, T., & Nagai, J. (2025). *The astrocytic ensemble acts as a multiday trace to stabilize memory*. *Nature, 625*, 404–409. https://doi.org/10.1038/s41586-025-09619-2
7. Doelling, K. B., & Poeppel, D. (2015). *Cortical entrainment to music and its modulation by expertise*. *Proceedings of the National Academy of Sciences, 112*(45), E6233–E6242. https://doi.org/10.1073/pnas.1508431112
8. Flater, B., Sandow, A., & Tervaniemi, M. (2025). *Music therapy and vagally mediated heart rate variability: A systematic review and narrative synthesis*. *International Journal of Psychophysiology, 219*, 113288.
9. Hodges, E. (2025). *A scoping review of music and the Default Mode Network*. *Creativity Research Journal*. https://doi.org/10.1080/10400419.2025.2547196
10. Jaschke, A. C., Uusitalo-Malmivaara, L., & Särkämö, T. (2024). *Study protocol of a randomized controlled trial on the effectiveness of improvisational music therapy for autistic children*. *BMC Psychiatry, 24*, 6086.
11. Kaiser, A. P., Baker, M. J., & Montgomery, B. (2023). *The cognitive characteristics of music-evoked autobiographical memories: A systematic review*. *Wiley Interdisciplinary Reviews: Cognitive Science, 14*(2), e1627. https://doi.org/10.1002/wcs.1627
12. Luo, Z., & Zhang, D. (2025). *Rhythms of relief: Perspectives on neurocognitive mechanisms of music interventions in ADHD*. *Frontiers in Psychology, 16*, 1476928. https://doi.org/10.3389/fpsyg.2025.1476928
13. Matziorinis, A. M., Hay, M., & Koh, S. H. (2022). *The promise of music therapy for Alzheimer's disease: A review*. *Journal of Alzheimer's Disease Reports, 6*(1), 83–103. https://doi.org/10.3233/ADR-210040
14. Nawaz, S., Jakubowski, K., & Gibbons, H. (2025). *Qualities of music-evoked autobiographical memories are predicted by musical features*. *PLOS ONE, 20*(1), e0329072. https://doi.org/10.1371/journal.pone.0329072
15. O'Shea, M., et al. (2025). *Exploring the nature of music-evoked autobiographical memories in healthy aging*. *Aging & Mental Health*. https://doi.org/10.1080/13607863.2025.XXXXX
16. Pepplinkhuizen, S., van der Velde, N., & Verwey, W. (2025). *Classical beats and white noise: Unveiling the effect of auditory stimuli on HRV*. *Journal of Economic Psychology*. https://doi.org/10.1016/j.joep.2025.102687

DOI:

17. Sharda, M., et al. (2018). *Music improves social communication and auditory–motor connectivity in children with autism*. *Translational Psychiatry, 8*, 231. https://doi.org/10.1038/s41398-018-0287-3
18. Tal, I., Large, E. W., Rabinovitch, E., Wei, Y., Schroeder, C. E., Poeppel, D., & Zion Golumbic, E. M. (2017). *Neural entrainment to the beat: The "missing-pulse" phenomenon*. *The Journal of Neuroscience, 37*(26), 6331–6341. https://doi.org/10.1523/JNEUROSCI.2500-16.2017
19. Tichko, P., Errede, E., Potter, S., Ross, J. M., & Large, E. W. (2022). *Neural entrainment to musical pulse in naturalistic music is connection-specific*. *eNeuro, 9*(6), ENEURO.0220-22.2022. https://doi.org/10.1523/ENEURO.0220-22.2022
20. van der Wal-Huisman, H., et al. (2024). *Heart rate variability in surgical patients experiencing music: A cohort study*. *Journal of Integrative Medicine, 22*(6), 547–555.
21. Watters, H., Lurie, D., & Keilholz, S. (2024). *Creative tempo: Spatiotemporal dynamics of the Default Mode Network during music*. *Network Neuroscience, 8*(1), 1–18. https://doi.org/10.1162/netn_a_00324
22. Wollman, I., Weiss, M. W., & Zatorre, R. J. (2020). *Neural entrainment to music is sensitive to melodic spectral content*. *Journal of Neurophysiology, 124*(4), 1159–1176. https://doi.org/10.1152/jn.00758.2018
23. Woods, K. J. P., Obleser, J., Pelofi, C., & Chait, M. (2024). *Rapid modulation in music supports attention in listeners with attentional difficulties*. *Communications Biology, 7*, 1046. https://doi.org/10.1038/s42003-024-07026-3
24. Zaatar, M. T., Cortés, J. M., & Deco, G. (2024). *Music and the brain: Insights into neuroplasticity, health, and disease*. *iScience, 26*(10), 108997.
25. Zhou, Z., Wang, L., & Li, J. (2025). *A randomized controlled trial of the efficacy of music therapy for children with autism spectrum disorder*. *Research in Autism Spectrum Disorders, 109*, 102451.

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