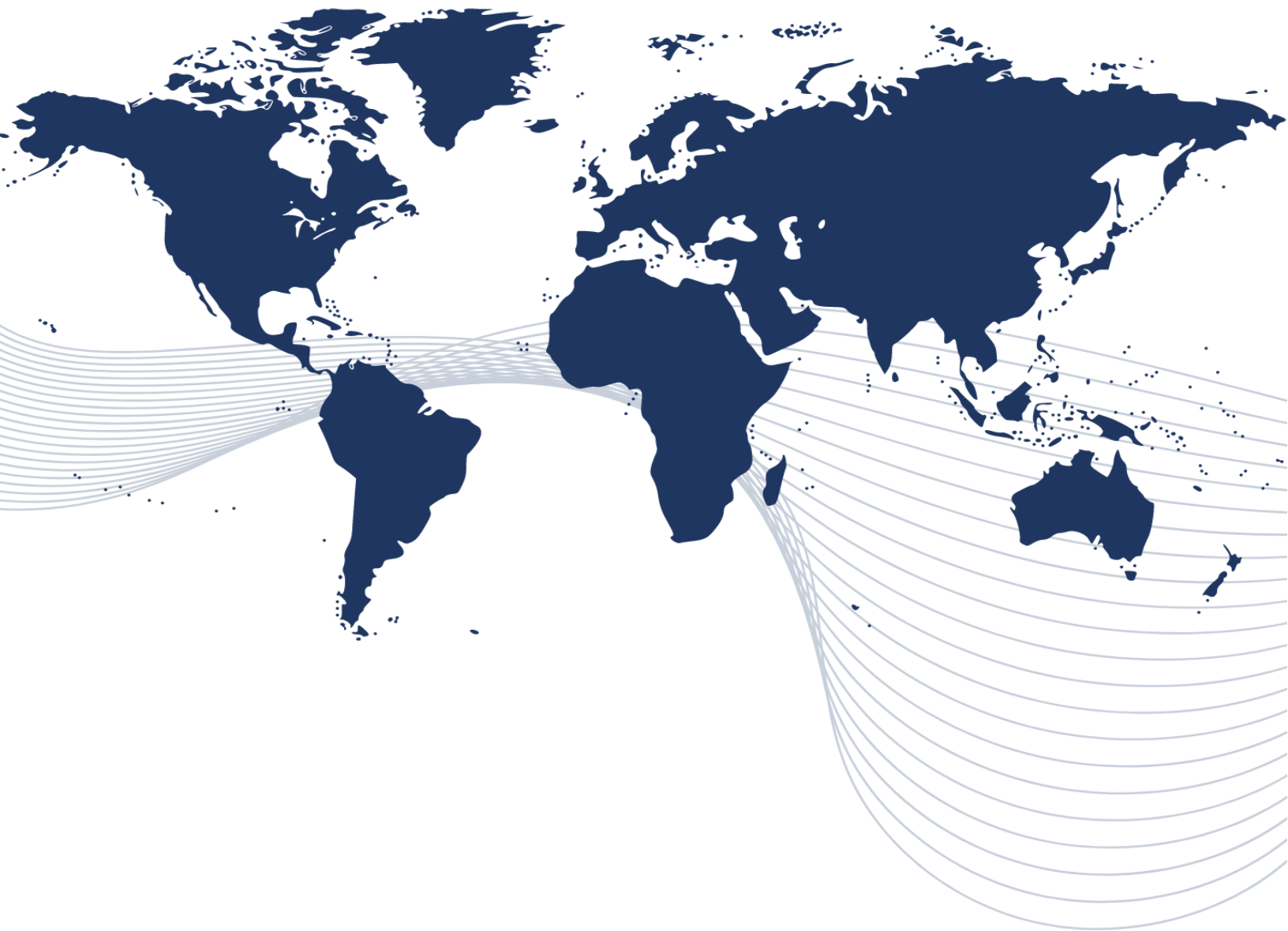


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The Sound of Syntax: How Sad Music Modulates Language Processing in the Brain

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Abstract

Language and music, although conventionally viewed as separate cognitive domains, exhibit same brain underpinnings and processing methods. Recent studies have commenced investigating the impact of emotional music, especially melancholic compositions, on linguistic cognition; nonetheless, this intersection remains little explored. This study rigorously evaluates empirical evidence about the influence of melancholic music on cerebral language processing, with the objective of consolidating existing knowledge and pinpointing theoretical and methodological deficiencies. The study employs a qualitative critical review methodology, utilizing peer-reviewed literature from cognitive neuroscience, psycholinguistics, and affective science, with an emphasis on research that incorporates neuroimaging, behavioral trials, and electrophysiological metrics. The results indicate that melancholic music activates brain areas associated with emotional regulation and language processing, such as the inferior frontal gyrus, superior temporal gyrus, and limbic structures. Exposure to melancholic music seems to augment semantic depth and emotional resonance in language understanding, while possibly hindering performance in tasks necessitating fast syntactic or phonological processing. The effects are influenced by the type of activity and individual variances, including empathy and musical training. The research enhances the comprehension of the emotional aspects of language processing and underscores the utility of emotionally evocative music in educational and therapeutic settings. It also advocates for more ecologically valid, longitudinal, and multimodal research to further clarify these intricate relationships.

Keyword: Sad Music; Language Processing; Neuroscience; Neurocognition; Music

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INTRODUCTION

Language and music are two of the most intricate and distinctly human cognitive abilities (Bidelman, Hutka, & Moreno, 2013). Historically, language has been regarded as a unique faculty linked to propositional, analytic reasoning, while music has been associated with emotional, holistic expression. Recent advancements in cognitive neuroscience have progressively contested this dichotomy, demonstrating significant overlap in the brain foundations and cognitive mechanisms that underpin both realms. Functional neuroimaging and electrophysiological research have revealed that areas such as the inferior frontal gyrus, superior temporal gyrus, and auditory cortex are engaged during both musical and linguistic activities, indicating a common network for syntactic and semantic processing.

Within this comprehensive framework of music-language interaction, the role of emotion especially sadness has surfaced as a significant although insufficiently examined aspect. Melancholic music, despite its correlation with bad emotions, is strangely perceived as enjoyable by numerous listeners. This phenomena, commonly known as the "paradox of pleasurable sadness," is ascribed to systems including emotional regulation, empathy, and artistic appreciation. Neuroimaging research indicates that listening to melancholic music stimulates brain areas associated with emotional significance, such as the amygdala, anterior cingulate cortex, and ventromedial prefrontal cortex, which are also involved in language processing (Perrachione, Fedorenko, Vinke, Gibson, & Dilley, 2013).

The convergence of melancholic music and linguistic processing constitutes a significant domain of investigation. The emotional effects of music have been thoroughly examined regarding mood regulation and therapeutic applications, although its impact on language cognition, especially at the brain level, is still inadequately comprehended. Considering the same neuronal framework and the emotional impact of melancholic music, it is likely that such auditory stimuli can influence language processing significantly (Patel, 2003).

Notwithstanding the expanding corpus of scholarship on music-language connections, some significant gaps remain. Primarily, the majority of research has concentrated on structural similarities between music and language, particularly in syntactic processing, while little considering the emotional aspect. Secondly, although the emotional impact of melancholic music has been investigated concerning subjective experience and mood management, few research has addressed its cognitive ramifications, especially for language comprehension, production, or memory. Third, current research often regards music and language as inputs processed sequentially, rather than exploring their simultaneous or interacting impacts on the brain (Temperley, 2022).

Furthermore, most empirical investigations have utilized neutral or upbeat music as auditory stimuli, so overlooking the distinct cognitive and emotional characteristics of sad music. This error is substantial, as melancholic music is not only widespread throughout cultures and historical epochs but also possesses a distinctive ability to evoke intricate emotional states that may affect advanced cognitive processes, including language. The absence of focused study on the impact of melancholic music on real time language processing encompassing syntactic parsing, semantic integration, and phonological decoding constitutes a significant theoretical and empirical void (Chandrana, 2023).

Moreover, although several research have investigated the therapeutic efficacy of music in language rehabilitation (such as in aphasia or developmental language impairments), these interventions frequently lack a sophisticated comprehension of how particular emotional tones in music affect linguistic results. The absence of this understanding constrains the development of effective music-based therapies. This study seeks to fill these gaps by doing a critical evaluation of empirical studies about the influence of melancholic music on language processing in the brain. The review integrates insights from neuroimaging, psycholinguistics, and affective neuroscience to elucidate the mechanisms by which melancholic music influences linguistic cognition. The primary aim is to clarify how emotionally significant auditory stimuli, especially those that elicit grief, engage with language-related brain networks and cognitive functions (Schellenberg & Peretz, 2008).

This study makes three significant contributions. Initially, it synthesizes diverse research domains in music cognition, language neuroscience, and emotion theory to provide a cohesive theoretical framework for comprehending the relationships among music, language, and emotion. Secondly, it emphasizes the methodological strengths and weaknesses in current investigations, offering a critical evaluation that might guide future experimental designs. Third, it suggests novel avenues for study and clinical practice, specifically in the creation of emotionally attuned language therapy for those with communicative deficits.

This study especially examines sad music, challenging the predominant focus on positive or neutral emotional stimuli in cognitive research and highlighting the significance of negative affect as a modulator of language processing. This enhances the comprehension of the emotional aspects of linguistic cognition, impacting both theoretical frameworks and practical applications in education, therapy, and human-computer interaction.

METHOD

This study employs a qualitative critical review methodology to comprehensively analyze and integrate empirical evidence about the impact of melancholic music on cerebral language processing. The process is founded on known principles of evidence-based synthesis and adheres to academic rigor, transparency, and replicability. The research employs a critical review methodology that transcends simple description to provide a conceptual contribution through the evaluation, comparison, and integration of findings from other studies. In contrast to systematic reviews that focus on comprehensiveness, the critical review prioritizes depth, theoretical understanding, and the recognition of conceptual patterns and deficiencies. This style is especially suitable for nascent interdisciplinary subjects, such as the convergence of affective music and neurolinguistic processing, where the literature is varied and methodologically diverse.

This review's primary data comprises peer-reviewed academic articles published in high-impact, Scopus-indexed publications. To guarantee the legitimacy and pertinence of the sources, only publications published in journals indexed in databases like Scopus, Web of Science, and PubMed were taken into account. The search was confined to research published in English from 2000 to 2024 to encompass the latest advancements in neuroimaging, psycholinguistics, and music cognition. The databases examined comprised ScienceDirect, SpringerLink, Oxford Academic, Nature, and Frontiers. The search approach employed keywords comprising combinations of terminology such as "sad music," "language

processing," "neuroimaging," "affective neuroscience," "semantic integration," and "music-language interaction."

A standardized data extraction strategy was established to guarantee consistency and transparency in the review process, notwithstanding the absence of physical equipment. This procedure encompassed predetermined sections including study objectives, participant characteristics, types of musical stimuli, utilized language tasks, utilized neuroimaging or behavioral methodologies, principal findings, and acknowledged limitations. A reference management tool, such as Zotero or Mendeley, was utilized to organize and annotate the literature. Every paper underwent independent evaluation and coding through a topic grid to enable cross-study comparison and synthesis.

The data collection approach adhered to a multi-phase methodology. An initial collection of articles was identified through keyword-based searches in designated databases. Titles and abstracts were evaluated for relevance, and duplicates were eliminated. In the second phase, complete papers were obtained and evaluated according to inclusion and exclusion criteria. Studies were included if they (1) utilized sad music as a stimulus, (2) investigated language processing results, and (3) implemented empirical methodologies such as fMRI, EEG, or behavioral studies. Research concentrating exclusively on music perception or language processing in isolation was omitted.

To improve reliability, a secondary reviewer independently evaluated a random sample of papers. Discrepancies were reconciled by dialogue and agreement. The final corpus comprised around 30–40 articles that fulfilled all inclusion criteria and offered adequate methodological detail for analysis. The chosen studies were examined through a thematic synthesis methodology. This entailed recognizing repeating patterns, theoretical frameworks, and methodological trends within the literature.

The thematic areas encompassed (1) neuronal convergence between music and language, (2) emotional influence on cognitive processing, (3) task-specific impacts of melancholic music on language comprehension or production, and (4) individual variances in affective and linguistic responses. Where relevant, results from neuroimaging studies were correlated with established brain regions linked to language (e.g., Broca's area, Wernicke's area) and emotion (e.g., amygdala, anterior cingulate cortex). This facilitated a neuroanatomical analysis of the interplay between melancholic music and linguistic processing. Alongside topic synthesis, methodological quality was evaluated using modified criteria from the PRISMA and CASP frameworks. This involved assessing the clarity of research enquiries, suitability of methodologies, transparency in data presentation, and strength of results.

FINDING AND DISCUSSION

Finding

The analyzed research demonstrate a complex and intricate connection between melancholic music and linguistic processing in the brain. The results are categorized into three themes: (1) neuronal overlap and co-activation, (2) emotional regulation of language processing, and (3) task-specific cognitive consequences. Neuroimaging studies consistently reveal the co-activation of brain areas often linked to music and language processing. Functional MRI studies demonstrate that listening to melancholic music activates the inferior frontal gyrus (Broca's area), superior temporal gyrus, and anterior insula areas also involved in syntactic

and semantic processing during linguistic tasks. Koelsch's neurocognitive model of music perception emphasizes the inferior frontal cortex's involvement in processing musical and linguistic syntax, indicating a common syntactic integration resource. Furthermore, research utilizing event-related potentials (ERPs) has demonstrated that melancholic music can influence early components like the N400, which is generally linked to semantic incongruity in language understanding. In an investigation, subjects exposed to melancholic musical snippets before reading semantically ambiguous words demonstrated heightened N400 amplitudes, signifying improved semantic sensitivity.

Melancholic music seems to affect language processing not just via common brain pathways but also by altering emotional states that impact cognitive efficacy. Numerous research indicate that melancholic music amplifies introspective and empathetic feelings, hence promoting more profound semantic processing. Sachs et al. (2015) discovered that individuals who listened to melancholic music prior to a narrative comprehension test exhibited enhanced memory of emotionally significant material and more sophisticated assessments of character motivations.

This impact is believed to be facilitated by the activation of limbic areas, including the amygdala and anterior cingulate cortex, which play roles in emotional regulation and attentional control. These regions may function as affective filters, amplifying the prominence of emotionally congruent verbal information. This implies that melancholic music may enhance the brain's focus on emotionally or metaphorically significant language. The emotional modulation effect is not consistently beneficial. In tasks necessitating swift syntactic parsing or phonological recognition, melancholic music has been correlated with prolonged reaction times and elevated error rates. This indicates that although melancholic music may enhance semantic involvement, it may also create a cognitive burden that disrupts more automatic or time-critical facets of language processing.

The influence of melancholic music on language processing seems to be significantly contingent upon the specific activity at hand. In semantic judgement tasks, melancholic music has been demonstrated to improve accuracy and interpretative depth. One study indicated that participants exposed to melancholic instrumental music were more adept at identifying tiny semantic inconsistencies in metaphorical sentences than those who listened to neutral or happy music.

Conversely, in phonological tasks like rhyme identification or syllable counting, melancholic music frequently resulted in diminished performance. This may result from the contemplative and emotionally engaging qualities of melancholic music, which might redirect attentional resources from superficial verbal elements. In ERP investigations, this is evidenced by delayed P200 and P600 components, which correspond to phonological and syntactic processing, respectively.

A significant discovery is the influence of individual differences. Individuals with elevated trait empathy or musical training exhibited more pronounced effects of melancholic music on language processing, indicating that personal characteristics and prior experiences determine the degree of cross-domain interaction. These findings highlight the significance of accounting for psychological and experiential factors when analyzing the cognitive impacts of music.

Discussion

This critical review aimed to investigate the impact of melancholic music on language processing in the brain, utilizing empirical research from cognitive neuroscience, psycholinguistics, and affective psychology. The results indicate a complex interaction between emotional auditory stimuli and linguistic cognition, facilitated by common brain pathways, emotional modulation, and specialized cognitive task requirements. The analysis revealed three key topics. There exists significant brain overlap between music and language processing, especially in areas like the inferior frontal gyrus and superior temporal gyrus. These regions are regularly engaged throughout both syntactic and semantic activities in language, as well as during the perception of musical structure. Secondly, melancholic music seems to regulate language processing by affecting emotional and attentional states. This modulation can augment semantic depth and emotional resonance in language comprehension, while potentially hindering performance on tasks necessitating quick phonological or syntactic processing. The impact of melancholic music is significantly influenced by the specific task and is regulated by individual variances, including empathy and musical training (Luo, Pan, & Fan, 2023).

These findings corroborate and expand upon prior research regarding the common cognitive and neurological resources associated with music and language. Koelsch's neurocognitive model of music perception asserts that music and language utilize shared syntactic integration resources in the brain, especially within the left inferior frontal cortex. The present review endorses this paradigm while introducing a significant subjective aspect: the emotional quality of music particularly sadness can influence the engagement of these shared resources. This indicates that the relationship between music and language is not only structural but also profoundly emotional (Brandt, Gebrian, Slevc, Belin, Fröhholz, & Sammler, 2012).

The emotional modulation noted in this review aligns with ideas of affective priming and embodied cognition. Melancholic music, by stimulating limbic structures like the amygdala and anterior cingulate cortex, may prepare the brain to engage with emotionally significant linguistic material more profoundly. ERP studies indicate augmented N400 responses to semantically incongruent words after exposure to melancholic music. These findings indicate that melancholic music may enhance sensitivity to meaning and complexity in language, likely via intensifying emotional engagement and attentional focus. Nonetheless, the effects of melancholic music are not consistently advantageous. In tasks necessitating swift or automated processing such as phonological discrimination or syntactic parsing—melancholic music has been linked to prolonged reaction times and diminished accuracy. This may result from the contemplative and emotionally engaging qualities of melancholic music, which might redirect brain resources from superficial verbal elements. These findings corroborate previous research on the dual-task interference effect, wherein emotionally appealing stimuli contend with cognitive activities for finite attentional resources (Chen, Affourtit, Ryskin, Regev, Norman-Haignere, Jouravlev, Malik-Moraleda, Kean, Varley, & Fedorenko, 2023).

Individual differences also appeared as a key issue. Individuals possessing elevated trait empathy or musical training exhibited a greater likelihood of improved language processing after being exposed to melancholic music. This indicates that individual temperament and previous experience determine the degree to which emotive music affects

language comprehension. These findings align with extensive studies regarding the modulatory influences of personality and competence on cognitive-emotional interactions. The ramifications of these results are both theoretical and pragmatic. They advocate for a more cohesive model of language processing that incorporates emotional context and affective priming. Conventional theories of language understanding frequently see emotion as ancillary; the present review indicates that emotion especially when elicited by music can significantly influence linguistic cognition. These discoveries have practical applications in education, therapy, and human-computer interaction. Incorporating emotionally appropriate music into language learning situations may improve engagement and retention. In clinical environments, melancholic music may be employed to enhance emotional expression and semantic richness in patients with language deficits, including individuals rehabilitating from aphasia (Turker & Reiterer, 2021).

Notwithstanding these contributions, the review also underscores certain shortcomings within the existing literature. A significant disadvantage is the absence of long term studies investigating the enduring effects of melancholic music on language processing. Most current research depends on short-term experimental paradigms, which may fail to encompass the complete spectrum of cognitive and emotional dynamics involved. Furthermore, numerous research employ artificial or rigorously controlled stimuli, potentially constraining ecological validity. Practical language usage frequently encompasses intricate, multimodal, and emotionally nuanced circumstances that are challenging to reproduce in experimental environments (Sachs, Damasio, & Habibi, 2015).

A further drawback is the methodological diversity among studies. The variations in musical stimuli (e.g., instrumental versus lyrical, Western versus non-Western), language tasks (e.g., reading versus listening), and neuroimaging methodologies (e.g., fMRI versus EEG) complicate the ability to reach conclusive findings or perform meta-analyses. Future research would benefit from enhanced standardization in experimental design and the implementation of multimodal imaging techniques capable of capturing both spatial and temporal dimensions of brain activity (Jäncke, 2012).

The review emphasizes the necessity for more sophisticated theoretical frameworks that consider the bidirectional and context-dependent characteristics of music-language interactions. Current models prioritize shared brain resources but frequently neglect the dynamic impact of music-induced emotional states on linguistic processing. Incorporating insights from emotional neuroscience, embodied cognition, and social psychology could facilitate the development of more complete models about the interaction of music and language in the brain.

This review conclusively demonstrates that melancholic music can affect language processing via common brain pathways, affective modulation, and task-specific impacts. These findings contest conventional distinctions across cognitive domains and underscore the significance of emotion in influencing linguistic cognition. The study enhances the comprehensive understanding of the human mind by integrating ideas from several disciplines, acknowledging the profound interrelations among sound, meaning, and emotion. Subsequent study ought to investigate these connections in more ecologically realistic contexts, assess long-term consequences, and analyze how individual differences moderate the influence of melancholic music on language. This work is promising for enhancing

theoretical understanding and guiding practical applications in education, therapy, and technology design.

CONCLUSION

This study aimed to rigorously investigate the impact of melancholic music on language processing in the brain, utilizing interdisciplinary research from cognitive neuroscience, psycholinguistics, and affective psychology. The findings indicate that melancholic music not only elicits emotional responses independently but also engages with linguistic cognition via common brain pathways and emotional regulation.

Neuroimaging and behavioral studies frequently demonstrate overlapping activity in brain regions, including the inferior frontal gyrus and superior temporal gyrus, which are crucial for both music and language comprehension. Furthermore, melancholic music seems to prepare the brain for profound semantic involvement, increasing responsiveness to emotional and metaphorical linguistic content. Simultaneously, it may incur cognitive costs in activities necessitating swift syntactic or phonological processing, underscoring the duality of its impact. These discoveries possess significant theoretical implications. They contest conventional compartmentalized models of cognition by illustrating that emotional states especially those elicited by music can influence fundamental linguistic processes. The findings emphasize the necessity for more comprehensive frameworks that consider the dynamic interaction among affect, attention, and language.

This research effectively introduces new opportunities for the application of music in educational and therapeutic settings. For example, melancholic music may be deliberately employed to enhance emotional involvement and semantic richness in language acquisition or therapeutic contexts. Nonetheless, its application must be meticulously adjusted to align with work requirements and individual variances, as its effects are neither consistent nor universally advantageous.

The review provides useful insights but also underscores some limitations in the existing research, such as methodological heterogeneity, restricted ecological validity, and an absence of longitudinal data. Rectifying these deficiencies will necessitate more standardized, multimodal, and contextually attuned methodologies in forthcoming research. This study underscores the understanding that language is not processed in isolation but is intricately woven into the emotional and sensory dimensions of human experience. Melancholic music, with its ability to elicit introspection and emotional depth, provides a distinctive perspective for examining the emotional aspects of language processing. Ongoing research in this domain promises to enhance our comprehension of the human mind and guide more comprehensive strategies for communication, learning, and well-being.

DECLARATION OF CONFLICTING INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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