Effect of Music on Cognitive Performance in Different Contexts

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Abstract

Music is a large part of people's lives, regardless of different sociodemographics or cultural backgrounds. People listen to music in varied contexts, from when one's attention is focused solely on the music (eg. during a concert) to performing other tasks (e.g., completing homework or scrolling through social media) to moments of inaction or while engaged in difficult tasks. Despite the prevalent use of music in our current world, the cognitive effects of listening to music in different contexts are not well understood and warrant further investigation. This paper examines two theories that provide possible explanations for the varying effects of music (i.e., distraction-conflict theory and mood-arousal hypothesis) and discusses how different elements of music (i.e., monotony and repetition, tempo and valence, and the presence of lyrics), personal characteristics (i.e., introversion, extroversion, sex, age, and musical training), and clinical symptoms (i.e., neurodegenerative and neurodevelopmental disorders) can either provide beneficial or detrimental effects. Findings in this body of research support the distraction-conflict theory and the mood-arousal hypothesis, where the combined effects of fulfilling simple tasks and listening to high arousal, positive valence music result in enhanced performance. This paper endorses the necessity to understand the relative effects of music based on different conditions.

Introduction

With today's access to music streaming services, the frequency of listening to music has skyrocketed. The largest streaming service, Spotify, reached over 118 million users worldwide in 2023 alone (Statista, 2024). Additionally, Spotify has been shown to increase overall music consumption for individuals on average by 49%, with such increases lasting even 25 weeks after individuals first adopt the service (Datta et al., 2017). This finding is significant because, after 25 weeks, the novelty of using a new application would have worn off, ensuring that the greater numbers of Spotify users are due to genuine interest. Much of music listening takes place while working on other tasks: 68% of participants reported in a United States survey that they multitask while also utilizing music (Statista, 2022). Whether to battle boredom, improve focus, or enhance performance, listening to music during different daily activities has never been more popular.

Research on the effects of music listening has, however, produced mixed data. Widespread interest in researching music began with the publication of the so-called "Mozart effect." This 1993 research finding, which sought to demonstrate a relationship between music cognition and cognitions relating to spatial performance, involved 36 college students yielding higher scores on spatial reasoning tasks after they listened to pieces of Mozart's music (Rauscher et al., 1993). However, attempts to recreate the Mozart effect have resulted in inconsistent results. Even decades later, research on the effects of listening to music while engaging in other tasks have proven to be inconclusive at best. While some researchers claim that music provides a slew of benefits, especially in improving levels of mood and mental stimulation, an excitatory, energizing physiological response by the autonomic nervous system (Lesiuk, 2005; Schellenberg & Hallam, 2005; Schellenberg et al., 2007), others have found it to take up substantial cognitive capacity, serving as a distraction to impair performance and memory (Cassidy & MacDonald, 2007; Furnham & Bradley, 1997; Reaves et al., 2015). Given

the clear divide between studies pointing to the benefits of music listening and others to its detriments, the question of how music impacts performance has become increasingly imperative to answer.

Research on music listening frequently examines the effects of playing music while engaged in various types of tasks that measure cognitive performance. Researchers test participants' cognitive abilities by assessing their performance through scores on various tasks, which capture different aspects of cognitive function. By examining how music impacts cognitive performance in specific scenarios, the degree to which music can benefit or hinder participants becomes evident.

This research examines the effects of listening to music while engaging in other tasks by reviewing existing empirical literature on cognitive performance in the presence or absence of music. Specifically, this review first focuses on the possible theories for how music improves performance, such as the distraction-conflict theory and the mood-arousal hypothesis. Second, the paper explores how performance on cognitive tasks tends to differ based on certain elements of the music, such as monotony and repetition, tempo and valence, and the presence of lyrics. Third, the review discusses how the impact of music on cognitive performance tends to vary with personal characteristics, like introversion, extroversion, sex, age, and musical training. Lastly, the paper examines the effect of music therapy on two different categories of neurological disorders, specifically, neurodegenerative and neurodevelopmental disorders.

Method

In order to review the relevant body of literature, related search terms for each section were identified and searched through Google Scholar. Papers were selected based on their relevance to music listening, cognitive performance, and each of the characteristics of music and music listeners that were explored in this paper. In addition to entering the topic keyword (eg., lyrics), each section also included the same general terms (ie., music, listening, "cognitive performance", effect) and their synonyms (eg., for effect, other keywords like impact, result, and influence).

Literature Review

Two Theoretical Hypotheses to Analyze the Impact of Music

The distraction-conflict theory explains the varied base levels of stimulation provided by different task difficulties

Psychology researchers have long grappled with the question of how exactly music affects cognitive performance. In order to provide a possible answer to this question, the distraction-conflict theory was developed. According to this theory, individuals require minimal cognitive processing to perform simple tasks, which leaves the unstimulated mind prone to wandering. A simple task is defined as a task that is generally easy to learn, repetitive, or familiar. Conversely, complex tasks refer to those which are novel, difficult, or have a high degree of variation, which require large amounts of cognitive processing to perform well (Baron, 1986). Baron claims that distractions like music can cause attentional conflict in two ways: structural and capacity interferences. First, structural interference occurs when two different inputs—the distraction and the task—warrant the same amount of physiological neural-mechanisms, such as processing two visual signals at the same time. Second, capacity interference occurs when a task takes up considerable attentional resources, making it difficult

to perform the task while tolerating the distraction. Additionally, Baron asserts that distractions in both simple and complex tasks evoke a state of increased arousal, which he refers to as “drive.”

Distractions enhance performance on simple tasks by narrowing attention or, in other words, presenting elevated arousal that prevents individuals from getting bored or distracted from the otherwise easy task. In turn, this permits the individual to focus on the task and ignore other irrelevant distractions (O’Malley & Poplawsky, 1971). On one hand, the small amount of attention that simple tasks generally require usually leads to mind-wandering. On the other hand, when music takes up that additional attentional processing, it not only doesn’t burden the individual but also prevents distractions, therefore enhancing cognitive performance (Gonzalez & Aiello, 2019). However, unlike simple tasks, complex tasks are sufficiently stimulating by themselves, and don’t require additional arousal to bolster task performance. Any further attentional conflict takes up the little mental capacity that is left, mentally overburdening and overstimulating the individual.

The mood-arousal hypothesis posits that more arousing and happier music enhances cognitive performance optimally

Another explanation, the mood-arousal hypothesis, was introduced because of a study by Rauscher and colleagues. The study reported that college students performed better on spatial tasks after listening to music composed by Mozart, as compared to lower performances after listening to non-musical relaxation tapes or during silence (Rauscher et al., 1993). Rauscher termed this positive outcome the “Mozart effect”. However, several inconsistencies were present. These included the fact that the Mozart effect only lasted 10-15 minutes, and that later studies seeking to replicate this effect have been unable to do so. (Steele et al., 1999; McCutcheon, 2000; Newman et al., 1995). Despite the limitations of the original study and the limited capacity to replicate this finding in future studies, the Mozart effect popularized quickly, and is one of the main ways people understand the effect of music on cognition.

The findings from various studies have disproved the phenomenon that was deemed the Mozart effect. In Chabris’ (1999) 16-study meta-analysis on the effect of Mozart’s music on the performance of cognitive tasks, a small intermittent beneficial effect that would normally support the Mozart’s effect was found. This finding was determined to be caused by the specific piece of Mozart’s music. However, Chabris concluded that the effect was because of a shared right hemisphere locus that produces “enjoyment arousal.” In other words, since sitting in silence or using relaxation tapes produces less arousal, their results had less of a positive effect. Thus, it could be that enhanced performance found in successful recreations of the Mozart’s effect could be a result of increased arousal levels, and not because of the specific Mozart piece of music. A 1999 study by Nantais and Schellenberg tested this possibility by having participants listen to either Mozart’s music or a narrated story by Stephen King. The study also had the participants record which audio they preferred. With both conditions of this study offering pleasant and engaging stimuli, the authors were able to disprove the Mozart effect. Therefore, the enhanced performance brought by the Mozart effect is not a result of a specific piece of music, but because the Mozart piece provided pleasant and engaging stimuli. Additionally, those who preferred Mozart’s music had improved performance if they listened to the music beforehand, and those who preferred Stephen King’s narration also had higher scores if they listened to the narration beforehand.

The mood-arousal hypothesis replaces Rauscher’s original hypothesis that the enhanced performance was a result of a specific type of music—Mozart’s—with the explanation that music

influences cognitive performance by changing states of arousal and mood. In these two emotional reactions, arousal is the intensity of the emotion while mood differentiates between positive and negative emotions (Husain et al., 2002). Specifically, pleasant music enhances performance by increasing mood and arousal, while unpleasant music decreases mood and arousal. Highly arousing music, even if it's pleasant, overstimulates the listener and impairs performance (Goltz & Sadakata, 2021). Optimal music to listen to during a task would therefore have a moderate arousal level and positive valence.

The Influence of Various Elements of Music

Monotony and repetition foster boredom

Music with monotonous or repetitive elements can be perceived as boring. Boredom, defined as, "the experience of being disengaged from the world and stuck in a seemingly endless and dissatisfying present…while wanting, but being unable, to engage in stimulating and satisfying activity" (Fahlman et al., 2013), often results in low arousal and decreased focus on tasks. The intensity of boredom can be caused by the presence of a variety of factors. The study by Hamilton and colleagues, which aimed to clarify the impact of certain factors on boredom proneness and examined data from males over a 2-year period, found that the intensity of boredom can be affected by how well the participant can cope with boredom (Hamilton et al., 1984). Likewise, the study by Fahlman and colleagues, which worked to develop a new measure of boredom, found that the intensity could also be affected by how many options are available to escape the situation and under- or over-stimulation of the participant (Fahlman et al., 2013).

Specifically, in the case of music, boredom is used as a disparaging judgment based on the listener. Menninghaus, while examining the interplay between positive and negative feelings in art, postulated that boredom prevents fulfilling engagement with the music as the scope of possible positive and negative emotions diminishes (Menninghaus et al., 2017). Elements of boredom in music include repeating melodies or rhythms within a piece, but also repetition between different pieces. In other words, listening to too many musical works by the same composer or even the same exact piece over and over again can lead to perceived boredom (Margulis, 2014). Likewise, a lack of variety, where the listener can predict upcoming parts of the musical piece, yields boredom. Because listeners expect the music to adhere to a specific mood or feeling, they may feel that the music is unimaginative, bland, or trivial when it does not fulfill their requirements. Listening to music with a specific goal may result in potentially increased dislike later, should the music not fulfill their expectations.

The degree to which tempo and valence are expressed should be matching to optimize performance

Researchers are divided on the effects of the tempo of the music that individuals are listening to while they perform other tasks. Musical tempo refers to the speed or pace of a certain piece of music. Some researchers say that background or instrumental music tends to inhibit performance when it is fast. In one study, where 25 participants read a passage and answered comprehension questions while listening to music with varying tempo and volume, both loud and fast music were found to disrupt reading comprehension (Thompson et al., 2011). Thompson and colleagues posited that it was harder to ignore due to the greater intensity and therefore greater amounts of auditory events per time provided by fast-paced music. Conversely, another study by Baldwin and Lewis, testing the impact of varying music tempo on

the participants' restoration of attentional resources, found that slow tempo music allows for more time to recover from its distractions. By preserving mental processing efficiency and providing a restorative environment, task performance is enhanced (Baldwin & Lewis, 2017). However, slow music was only found to enhance task performance by increasing reaction time, and therefore preserving processing efficiency, not accuracy. Baldwin and Lewis concluded that there may have been a high ceiling effect for accuracy, since most of the participants achieved near the highest scores. In addition, Quan and colleagues, in a study that analyzed the impact of different tempo music on executive attention in children, found that reaction time is generally more sensitive to tempo changes as compared to accuracy (Quan et al, 2022).

Others hold that fast tempo music bolsters performance. In Schellenberg et al.'s 2007 experiment, 5-year-old Japanese participants drew more creative and energetic art for longer periods of time when listening to faster music compared to a slower piece. Additionally, Chie and Karthigeyan (2009) reported that faster music leans towards improving memory, and Day et al. (2009) found that it also caused participants to make more accurate decisions in their study with 40 college students who listened to varying tempo music. Slow music, by contrast, may hinder performance. When participants finished three cognitive processing tests while listening to fast, slow, and no-music conditions, slow music led to worse performance while the fast and no-music conditions were almost the same (Lin et al., 2023). Slow tempo music increased necessary processing time and thus inhibited performance.

Is there an explanation for these contradictory results? Tempo is usually correlated with arousal levels, where fast tempo music increases arousal and slow tempo music decreases arousal. Valence, the mood of the music, is also a factor. Listening to music with high valence, which is usually in a major key, boosts the listener's mood positively. Similarly, low valence music, generally in a minor key, causes negative shifts in mood. Husain et al., (2002), in a study where 36 undergraduates performed a spatial task while listening to music with varying tempo and valence, found that the enjoyment ratings depended on specific combinations of tempo and mood. Specifically, performance was optimized if positive valence music is also played at a fast tempo. Negative valence music was matched with slow tempo music.

The effects that tempo has on arousal and valence on mood are completely separate, according to a meta-analysis of 22 studies (Pelletier, 2004). An increase in tempo does not imply a boost in mood. The previously discussed optimal combinations of tempo and valence need to be separately fulfilled. High valence, fast tempo music would most likely require a musical piece in the major key played at high speeds, while low valence, slow tempo music would be matched to a piece in the minor key played at slow speeds. The effect on performance is consistent with the arousal-mood theory, discussed in a previous section. The optimal piece of much would have positive valence and moderate arousal, as high arousal could lead to overstimulation. Fast tempo and therefore high arousal enhances performance to a higher degree compared to slow tempo with low arousal, however, the latter combination is still optimal if either of the two conditions are present.

The presence of lyrics always results in hindered performance

Overall, a systematic review seeking to clarify the impact of background music on cognitive task performance concluded that the presence of lyrics significantly hindered performance when performing other tasks. Specifically, lyrics impede memory-related tasks and reading comprehension (Cheah et al., 2022). Instrumental music, which doesn't have lyrics, is less likely to impact cognitive performance. This also applies to lyrics of a foreign language,

where the lyrics are perceived as unintelligible and therefore not distracting (Chew et al., 2016). When the same song was transformed into a native dialect, the negative effects disappeared. Furthermore, the only positive effects discovered when listening to music happened during instrumental pieces. Additionally, Souza and Leal Barbosa found that in a study of 123 participants, the presence of lyrics in music resulted in perceived impairment, while instrumental music was seen as beneficial (Souza & Leal Barbosa, 2023).

This general negative effect may be due to either semantic (the language or meaning in music) or phonological interference with the current task (Vasilev et al., 2023). The presence of lyrics in music is always detrimental, no matter if non-lyrical music leads to better or worse performance compared to silence.

Personal Characteristics Vary the Effect of Music Even Further

Introversion vs. extroversion in Eysenck's theory of personality clarifies the impact of having different personality types

Introverts and extroverts require different amounts of arousal to reach optimal performance. This is explained in Eysenck's theory of personality, who conducted a study to confirm his theory. Introverts, who tend to be shy during socialization and are more closed off in general, were found to experience higher levels of arousal when faced with lower-intensity situations as compared to extroverts. Eysenck additionally concluded that introverts typically have greater arousal at rest, thus, the presence of music would surpass their optimal levels of stimulation quickly, leading to over-stimulation. In contrast, extroverts possess less arousal at rest and would therefore benefit from the additional stimulation provided by instrumental music (Eysenck, 1967). To this extent, introverts generally display aversion to situations with external stimulation. In complete opposition, extroverts willingly partake in these same situations. Instrumental music would therefore inhibit introverts to a greater degree when compared to extroverts, at least according to the theory.

Many studies have found that instrumental music impacts introverts more negatively during different tasks (Cassidy & MacDonald, 2008; Furnham & Bradley, 1997; Daoussis & McKelvie, 1986). According to Eysenck's theory of personality, introverts should be negatively affected and extroverts should be positively.

Different biological sexes lead to different degrees of impact by music

Inherent biological differences in men and women lead to different ways of processing music, and impact resulting performance on tasks. There is evidence that males' arousal levels increase faster and easier when significant stimuli is present. In addition, some studies have found that they need more time to return to their original arousal levels as compared to females (Fabes, 1994; Haviland & Malatesa, 1981; Moss, 1974). For lyrical music specifically, Schirmer et al., (2002) posited that females are initially affected more by prosodic (rhythm and intonation of language) and emotional signals from words. Conversely, Schirmer and colleagues found that males start off by processing word valence instead. Additionally, a study by Jing and colleagues (2012), which tested gender differences in completing simple and complex tasks, found that the collective processing of both prosody and words may be more efficient in females as compared to males. Males tend to be impacted by external stimuli more than females. Thus, females may hold an advantage when listening to music and completing other tasks.

Old age not only inhibits cognitive performance generally, but also decreases the beneficial effect of music

Aging has been found to inhibit cognitive performance while listening to music. (Reaves et al., 2015; El Haj et al., 2014). Exempting the non-musical related impairments that come with old age, such as declines in frontal-based executive control processes (Braver & West, 2007; Campbell et al., 2012), the processing in older adults may be less effective in suppressing task-irrelevant stimuli. Hasher & Zacks (1988) proposed, in their literature review that studied the effect of age on memory, that these memory-related impairments are the result of failures when encoding and retrieving information. When information is encoded, individuals are permitted to focus on task-relevant stimuli instead of task-irrelevant stimuli, and when information is retrieved, they can narrow their attention to relevant memory searches. It is likely that music inhibits both of these mechanisms, leading to worse performance.

The performance of individuals with musical training, while exposed to music, are both superior to those without and experience fewer negative effects

Positive effects of music have been found to significantly enhance the performance of professionally trained musicians compared to non-musicians. Some studies have found that even if music improves both groups' cognitive abilities, the degree to which their performance is strengthened is noticeably higher. When ignoring the advantages that music training provides even when music is not being played, in general, musicians are less affected by distracting environments like those including music (Kraus & Chandrasekaran, 2010; Patston & Tippett, 2011). A 2012 study by Strait et al. that examined the relationship between 31 musically-trained children and processing of speech concluded that if children engage in musical training, their attention levels rise above those without music training during situations of soft instrumental music. In other words, their ability to focus in distracting environments increases. Since musicianship is connected to adaptations in the cerebral cortex and the brainstem, as found in a study by Bidelman et al. (2014), musicians may perform better when music is present.

Therapeutic use of music in treating neurological disorders

Music is commonly used to treat patients with neurological disorders. Its ability to elicit a wide range of emotions, induce and focus attention, enhance memory, bolster speech and language communication, and improve motor skills helps to preserve cognitive function and memory, as well as boost mood. The rehabilitative effects of musical interventions (including music therapy) have been proven through empirical research, especially for diseases that cause deficits in emotions, attention and sensory functions, memory, communication, and motor functions (Särkämö et al., 2013). Music therapy can be active or passive. Active music therapy includes the direct participation of individuals, and can include elements of exercise, dance, and music creation. Conversely, passive music therapy only consists of more idle activities such as listening to music. Both types of music therapy have been found to diminish the symptoms of certain diseases. The following sections explore the specific effects of music therapy on two different types of disorders: neurodegenerative and neurodevelopmental.

Decreasing the symptoms of Alzheimer's disease and dementia using music listening

Music is notably effective in treating major neurocognitive disorders, the most being dementia. Initially, dementia is determined through the deterioration of emotional control, social behavior, and several cognitive functions over time (Knopman et al., 2001). As the symptoms of

dementia progress, the loss of motor function grows more apparent (Brinton, 1999). The escalating decline in cognitive functions, such as memory and language abilities, is however the primary symptom of dementia (American Psychiatric Association, 2013).

Music can affect people with dementia even until the end stages of neurocognitive disorders, even as cognition worsens over time. Indeed, regions of the brain that control musical memory are near the last areas that display atrophy (Aldridge, 1996). Music also provides a way to improve the emotional health of people with dementia. In these situations, where verbal language declines, music makes non-verbal influence possible (Brotons & Koeger, 2000). In terms of cognitive performance for people with dementia, music's effect has not been researched as thoroughly. Nevertheless, Gallego and García (2017), after playing music that aligned with the participants' music preferences, found that listening to music diminished most symptoms of Alzheimer's disease, which is the most common type of dementia and therefore contains most of the same symptoms. Gallego and Garcia also reported that no matter the severity of dementia, memory and orientation in time and place improved as tested by the Mini-Mental State Examination. Music's enhancing effect may have been a result of its impact on neuroplasticity mechanisms (the neural networks in the brain that allow for change) or its effects on increasing arousal levels, improving motor performance and learning. Lastly, language and speech processing have also been found to improve because of music. A study that repeatedly tested individuals with Alzheimer's while in music therapy reported that music positively impacted their speech content and fluency (Brotons & Koeger, 2000).

Compared to other diseases, Alzheimer's disease may be especially well-suited for enhancement by music. A 2015 study inspected the brain using a 7 T functional magnetic resonance imaging technique,which uses a powerful magnet and radio waves to track blood flow in the brain, with the goal of figuring out how the brain's musical memory regions were impacted by Alzheimer's. It was found when these areas were examined for biomarkers of Alzheimer's that despite the consistent levels of amyloid disposition when compared to the control group, there had been a significant decline in cortical atrophy (Jacobsen et al., 2015). This is evidence that musical memory areas are mostly unaffected by Alzheimer's, and demonstrates how music therapy recovers memories in people with the disease so well.

Parkinson's disease can be treated with passive music therapy

Parkinson's disease, one of the two most common neurodegenerative disorders (second to only Alzheimer's disease), is a disabling age-related disorder recognized through the loss of dopaminergic neurons (Walsh & Selkoe, 2016). In other words, it is caused by decreased dopamine production, a neurotransmitter in the brain. Postural instability, resting tremor, bradykinesia, muscular rigidity, freezing, and gait impairment are some of the most prominent signs of Parkinson's disease (Bloem et al., 2015). However, damage to cognitive functioning is also present (Wirdefeldt et al., 2011).

Since Parkinson's main symptom includes impaired motor function, most music therapy is active and involves mild exercise, dance, or rhythmic aspects. While testing the cognition of participants, Pohl et al. (2013) used the Ronnie Gardiner Rhythm and Music Method, a method that combined rhythm, music, and movement to improve cognitive and motor skills. Pohl et al. reported higher scores on the verbal memory text recall tests after undergoing the method. Specifically, for cognitive performance, the method is intended to raise mental flexibility and general alertness, and thus the ability to concentrate. Spina et al. (2016) also found a beneficial effect on cognition after participants with Parkinson's disease underwent a music therapy

program, which consisted of sessions with music creation, singing, and dancing. At the end of the program, frontal lobe function was observed to have been enhanced. This included working memory, attention, cognitive flexibility, and processing speed, showing how music benefits those with mild cognitive impairments.

Music therapy can overcome the social, emotional, and cognitive deficiencies that are caused by autism spectrum disorder

Autism spectrum disorder (ASD) is an umbrella term for a range of disorders. These include developmental brain disorders that cause problems in communication like autism, Asperger, pervasive developmental disorder, and disintegrative disorder (Belousova & Zavadenk, 2018). ASD is primarily distinguished by problems with interpersonal communication and repetitive behaviors, but also includes alternations in many different brain networks (APA, 2013). Most studies involving music therapy are aimed towards improving the general social-emotional difficulties that come with ASD. However, social communication blocks could come not only from changes in the brain socially, but also from deficits in sensorimotor and cognitive functions (Ronconi et al., 2016). In Sharda et al.'s 2018 study, 8-12 weeks of music intervention were found to improve social communication and functional brain connectivity.

Researchers have found that some people with ASD have been found to have deficiencies in reading comprehension and language acquisition (Asberg et al., 2010). To find out if music has an enhancing effect, Schwartzberg et al. (2016) had 29 children with ASD perform five comprehension checks while listening to live music-based short stories. In the end, both short- and long-term increases in cognitive function were observed, and Schwartzberg et al. concluded that the effect may have been due to increased cognitive arousal and attention span.

Listening to music with attention deficit hyperactivity disorder (ADHD) results in lessened symptoms

Attention deficit hyperactivity disorder (ADHD) is the most prevalent neurodevelopmental disorder, occurring in an estimated 5-10% of the world (Erskine et al., 2016b). The most prominent and dangerous effects of ADHD occur during developmental stages, resulting in substance use, a higher risk of dropout, and increased chances of unemployment in young adulthood (Erskine et al., 2016a). Similarly, ADHD in adults can cause a variety of problems. Dalsgaard et al. (2015) associated adult ADHD with high rates of mortality because of its association with several factors, such as higher chances of traffic accidents and an increased risk of sustaining injuries, where ADHD lingers in around 65% of adult cases (Faraone et al., 2005).

Music therapy, both active and passive, has been used to lessen symptoms of many disorders, such as ADHD. People with ADHD experience problems with timing-related rhythms (Puyjarinet et al., 2017), struggle with perceptual timing tasks that require participants to distinguish the difference between milliseconds and seconds, and exhibit poorer performance for temporal foresight and motor timing (Noreika et al., 2012). Researchers have found that music can speed up the growth of timing skills and therefore the long-term development of the auditory cortex (Serrallach et al., 2016). Therefore, music therapy is a viable way to help those with ADHD. Additionally, Madjar et al. (2020), while finding out if calm music helped the reading comprehension of preadolescents with ADHD, concluded that calm music assisted their control over their autonomous responses and bolstered their performance. Although ADHD should

result in an easier time getting distracted, the music becomes the primary distraction and masks other, more irrelevant distractions.

Conclusion

The first section of this paper focused on theories to explain the impacts from different factors. Specifically, the distraction-conflict theory explains why music can have differing effects on simple and complex tasks. Simple tasks do not require large amounts of attentional resources, unlike complex tasks. When music takes up the leftover cognitive resources that would otherwise get channeled into mind-wandering, this behavior is reduced. However, for complex tasks, the same scenario has been found to lead to overstimulation (Gonzalez & Aiello, 2019). Additionally, the mood-arousal hypothesis states that pleasant music enhances performance and arousal to some extent, while unpleasant music does the opposite (Goltz & Sadakata, 2021). Taken together, the distraction-conflict theory and the mood-arousal theory help explain differential effects of music listening on cognitive performance, as the former accounts for different outcomes relating to the level of task complexity and the latter justifies varied outcomes relating to the arousal and valence of music.

In the second section of the paper, empirical studies that examined the various impacts of different elements of music were discussed. Some studies found that monotony and repetition in the music subjects listened to resulted in boredom and therefore worsened performance (Margulis, 2014). Husain and colleagues (2002) found that faster tempo and high arousal should be paired together to produce optimal performance, and slower tempo with low arousal to a lesser extent (Husain et al., 2002). Moreover, studies have consistently found that the presence of lyrics hinder cognitive performance (Souza & Barbosa, 2023; Vasilev et al., 2023). More specifically, Chew and colleagues (2016) conducted a study which found that if words can be distinguished (i.e., not in a foreign language or an instrumental piece), cognitively demanding tasks will be completed more poorly.

The mood-arousal theory and the distraction-conflict theory contribute to our understanding of the aforementioned research findings on the effect of music on cognitive performance, however, these two theories are only somewhat supported by the data. Empirical support is lent to the mood-arousal hypothesis given that matched tempo and valence were found to optimize performance. However, results were inconsistent with the aspect of the mood-arousal hypothesis that predicted enhanced performance when slower tempo and lower valence were present. According to the mood-arousal hypothesis, a slower tempo and lower valence should result in inhibited instead of the enhanced performance found. Other inconsistencies were also found in the distraction-conflict theory. While repetition and monotony in a piece could lead to boredom and therefore inferior performance, it could also minimize the amount of distraction the music causes. Gonzalez and Aiello (2019) found that higher music salience, which has greater complexity and louder volume, leads to enhanced simple task performance. Thus, decreased repetition and the resulting increased music complexity should lead to increased concentration, at least until it reaches the level of overstimulation.

The third section of the paper examined the impact of personal characteristics on cognitive performance based on various studies. In general, studies found that introverts, males, older people, and the absence of training in singing, playing an instrument, or other musical endeavors led to worsened cognitive performance. According to Eysenck's 1967 study, introverts always perform worse than extroverts when listening to music and completing a task,

as introverts exhibit a higher level of resting arousal and are more easily overstimulated. Haviland and Malatesa (1981) found that males are more easily impacted by external stimuli, and concluded that because their arousal levels increase more quickly, their performance is hindered more. A study by Hasher and Zacks (1988) found that older individuals showed worse cognitive performance in the presence of music. The finding that aging eventually leads the encoding and retrieval mechanisms in the brain to weaken helps explain this result. Lastly, experience with musical training leads to enhanced performance, as they are less affected by external stimuli and therefore less likely to get distracted (Strait et al., 2012).

With respect to the implications of this body of literature, it is important to consider the populations which engage in and may be negatively or positively impacted by music listening multi-tasking practices. Studies have found that individuals tend to have somewhat accurate perceptions of the effects of listening to music on cognitive performance. Goltz and Sadakata's (2021) experiment where 140 participants completed an online questionnaire, self-reporting on their music habits while engaging in other tasks. For every single type of task, participants (even those who believed in music's beneficial effects) reported that they use music less as tasks become harder. Participants also favored non-vocal, classical, and calm music while they were completing difficult tasks but were less considerate when completing easy tasks, matching the distraction-conflict theory. These choices match the two theories discussed, where the more cognitively demanding difficult tasks would be overburdened by lyrical music. It must be noted that while calm music can be beneficial, energetic music can also boost arousal to a degree, therefore enhancing cognitive performance. The majority of the participant's musical beliefs still aligned with existing research, however, some effects are not well known.

Being aware of the effects of listening to music while completing other tasks is especially important in current times. Because of rapidly improving technology and the COVID-19 pandemic, desk jobs and remote work have become more frequent. According to an April 2020 census for the United Kingdom, 46.6% of people working in jobs also have worked at home, and 86% of those did so because of the COVID-19 pandemic (Office for National Statistics, 2020). Since music is frequently used in these types of jobs, knowledge of the exact effects of the music is important for job productivity.

The fourth section of the paper recognized that listening to music also has real clinical applications. Music therapy includes all the effects of music previously discussed, but also includes more active variants. For the four neurological disorders covered (i.e., Alzheimer's disease, Parkinson's disease, autism spectrum disorder, and ADHD), the presence of music lessens their symptoms and overall improves performance. Compared to pharmaceutical options that only temporarily subdue symptoms and lead to side effects, music is a safer, alternative option.

Limitations

With respect to the limitations of the studies reviewed in this paper, a pattern of considerably more females in each study was found. This is especially notable, given that females tend to be affected by the presence of music less than males, thus skewing the effects of the studies into having less of an effet. Also, exempting the studies that examine the impacts of music therapy, which are focused on older people and the studies that specifically look at younger children, most experiments are near an average age of 21. Research is lacking on the effects of music on middle-aged people, as focusing on the extremes of the age scale only limits the available findings.

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