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A Systematic Review of The Impact of Music on Attention, Mood And Driving Behavior

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ABSTRACT

The automobile is the primary mode of transport for most families, but automobile accidents remain the leading cause of death for children and young adults. The most common cause of automobile accidents is incorrect driver action and research aims to minimize the factors that contribute to this, specifically driver aggression and inattention. Music has been shown to have an impact on driving and may be a useful tool to help mitigate these behaviors that can increase the risk of automobile accidents. The aim of this study is to systematically review and summarize the current published literature on the impact of listening to music whilst driving on the driver's behavior, mood and attention.

We conducted a systematic review of academic literature on EMBASE, PubMed and Scopus on the 12th of August 2024. We searched for articles relating to driving, music and behavior using key terms. No language or date restrictions were applied.

18 studies were included in the review. One was a systematic review, the remaining 17 were experimental studies. 89% of studies used a driving simulator to evaluate driving accuracy and safety. 95% of experimental studies included only participants who were under the age of 30.

Overall, music tempo had a negative impact on driver behavior, with participants listening to high tempo music experiencing more arousal, resulting in them driving faster and more prone to distraction. The presence of music which was low or neutral tempo had a positive impact on drivers' ability to focus. Genre of music and the comparison of instrumental versus lyrics was understudied. We recommend that drivers who choose to listen to music avoid high tempo choices as these may increase arousal and risk of automobile accidents.

Keywords: Systematic review, driving, behavior,music and attention

1. INTRODUCTION

1.1 Impact of Cars:

As the private car remains the primary choice for daily travel almost everywhere in the developed world [1], with more and more individuals becoming reliant on cars as their main mode of transportation [2], in turn the risk of car-related accidents and injuries increases.

Automobile accidents remain the leading cause of death for children and young adults, with traffic accidents responsible for 1.3 million deaths a year [3]. In addition to deaths, these accidents result in life-changing injuries for an additional 20-50 million individuals annually [3].

1.2 Impact of Driving:

There are a multitude of reasons why automobile accidents occur, many of which are outside the control of the individuals involved, such as technical malfunctions or difficult road conditions [4]. However, the most common cause of automobile accidents is incorrect driver action,accounting for up to 75% of all incidents [4].

With an ultimate goal of reducing the frequency and severity of car accidents, minimizing the factors that contribute to incorrect driver action is a priority in behavioral research.
Two key factors that are repeatedly associated with incorrect driver action and increased likelihood of car accidents are driver aggression and inattention.

Aggressive behavior whilst driving is very common, with 78% reporting having engaged in at least one aggressive driving behavior (such as tailgating, yelling at other drivers, blocking those trying to change lanes) [5]. An additional issue with an aggressive driving style is that the individual may be focused on emotions rather than driving. They may fail to allocate attentional resources to driving safety, as their attention is focused on the demands of emotion [6].

1.3 Impact of Music:

Music has been shown to have an impact on driving and may be a useful tool to help mitigate these behaviors that can result in more driving accidents [7].

The tempo of music, for instance, has been suggested to influence a driver's emotional state and attentiveness, potentially leading to either enhanced focus or increased distraction [8]. Conversely, slow-tempo music is associated with calmer driving. This tempo aligns with the average resting heart rate, promoting relaxation and reducing the likelihood of aggressive driving [7]. Additionally, different musical genres have varying effects on mood and attention,potentially influencing driving performance [9].

The relationship between music, driver behavior, and attention is a complex area of research that highlights how different types of music can influence driving performance and safety [10]. The way that people react whilst driving also depends on their mood, and since music can change the listener's mood, it affects the quality of driving [3].

Research suggests that different types of music can influence driving patterns by affecting emotional states, attention, and reaction times. For instance, drivers listening to dance or heavy metal music were observed to drive faster and make sudden accelerations or braking maneuvers [11].

Listening to music while driving can also boost a driver's level of arousal. Additionally, listening to music can enhance not only the driver's driving quality but also their physiological performance. Listening to music while driving is effective in controlling stress, calming emotions, and preventing driver drowsiness [12]. However, this boost in arousal can also have negative implications for driver safety. According to a study by the American National Highway Traffic Safety Administration, in-vehicle driver distraction, such as listening to music, is responsible for 25% of traffic accidents [13].

In the study by Ghojazadeh et al. [7], the authors conducted a systematic review and meta-analysis to evaluate the effects of music on driving performance as well as its impact on physiological and psychological indicators. The findings suggested that listening to music while driving can improve driving performance by enhancing focus and reducing fatigue. However, the effects on physiological measures such as heart rate were mixed, with some studies showing an increase in arousal and others reporting a calming effect.
Overall, the study concluded that music could have both positive and negative effects depending on factors like the type of music, driving conditions, and individual differences.
In the current review, we will build upon these findings to consider which types of music had a positive or negative effect and offer recommendations to drivers on their music use.

2. AIM

The aim of this study is to systematically review and summarize the current published literature on the impact of listening to music whilst driving on the driver's behavior, mood and attention.

3. OBJECTIVES

The objective of this review is to provide guidance on the genre, tempo and suitability of music to listen to whilst driving to minimize hazards and maximize attention. These guidelines will be based on the summary of current findings on driving behavior and the impact of music.

4. HYPOTHESES

1. We hypothesize that different music genres will impact a driver's ability to respond to potential hazards and safety

2. Listening to high tempo music (compared to low tempo music) will result in more aggressive behaviors whilst driving and less attention

3. More aggressive behaviors and lower attention levels will result in more accidents whilst driving

4. Not listening to any music will result in more focused drivers, less aggressive behavior and safer driving (indicated by fewer accidents)

5. METHOD

5.1 Search Strategy

We conducted a systematic review of academic literature on the 12th of August using the followingsearch terms.

We searched EMBASE using ('car driving'/exp OR 'car driving') AND ('music'/exp OR music). We also searched PubMed using (automobile driving[MeSH Terms]) AND (music[MeSH Terms]). Finally we searched Scopus with (driving[Key words]) AND (music[Key words]). No language or date restrictions were applied. Reference lists of returned search resultswere also screened for additional suitable articles.

First, all articles were reviewed by title, and ineligible ones were excluded. In the next steps, the abstract and the full text of the studies were evaluated. All steps of study selection were done independently by two authors. Disagreements and uncertainties were resolved through discussion. The PRISMA 2009 flowchart was used to report the results of the selection and screening process. This is reported in Figure 1:PRISMA Diagram below.

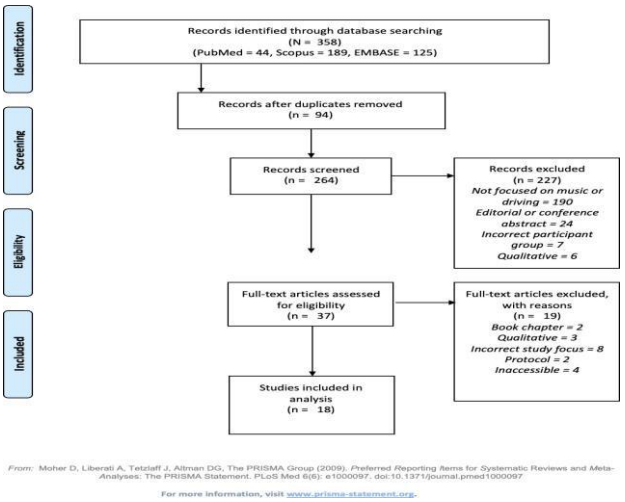

Figure 1: PRISMA Diagram of Study Selection Process

5.2 Study Selection

We evaluated search results compared to our inclusion and exclusion criteria (outlined in Table 1). All results that did not meet these criteria were not included in our review. Studies were excluded if they had no reference to driving behavior or music, inappropriate study designs (cohorts, surveys), assessing the effect of different music delivery formats or were focused on participants with a specific medical condition.

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Driving automobiles Focus of the study is on behavior whilst driving Music use isincluding Published academic literature	Conference abstract Not published academicliterature Non-human participants Not behavior, driving or music in the study aim Not driving Not music Qualitative or mixed-methods Participants have a specific medical condition Duplicates

5.3 Data Extraction

The data extraction form was designed in the Office Excel 2019 software (Available from: https://office.microsoft. com/excel). Extracted information in the form includes: first author, year of publication, first author affiliation (country), participants' number, participants' age (Mean /Median), participants' sex, study aim and method summary, music selection process, use of driving simulator, aspects of driver behavior measured, if behavior as self or researcher rated and the aspects of music evaluated (genre, tempo and volume).

6. RESULTS

6.1 Overview Of Included Studies

The search yielded 358 papers, of which 264 were removed as duplicates. After screening based on titles and abstracts, 227 records were excluded. 37 studies were excluded evaluating full texts based on exclusion criteria, and 18 studies were included (Figure 1: PRISMA).

The studies included in this review are available in Table 2 provided as an Appendix. All studies were published between 1999 and 2023, reflecting a broad time span of research into the effects of music on driving behavior. The total number of participants across all studies were 2,889 with an average of 145 participants per study.

The studies varied in sample size, ranging from as few as 5 participants [14] to as many as 1780 [15]. A significant percentage of these studies (80%) used driving simulators to evaluate driving behavior. Music was selected by the researchers in half of the studies, while in the remaining study's participants chose the music during the driving task.

Most studies (70%) employed a cross-sectional design, with the rest employing designs such as repeat measures

or independent measures. Additionally, there was one systematic review included [7] with the remainder experimental studies.

6.2 The Effect of Music Tempo on Driving

The tempo of music played during driving tasks emerged as a significant factor in multiple studies, with faster tempos generally increasing arousal and driving speed. Studies by Navarro [16] and Karageorghis [9] both found that faster music tempos led to increased arousal, which was associated with more aggressive driving and risky behavior. In contrast, slower tempos appeared to have a calming effect, with Karageorghis [9] reporting that slow tempo music improved mood and reduced braking behavior. The findings suggest that music tempo is a key variable influencing both the mental state of the drivers and their driving performance. Specifically, faster music tends to elevate driving speeds and arousal levels, while slower music has the opposite effect, leading to lower mental demand and more cautious driving behavior.

6.3 The Effect of Music Genre On DrivingFocus

The genre of music also influenced driving behavior, although the results varied depending on the type of music used. In studies where participants were allowed to select their own music, a broad range of genres was included, from hard rock and metal [17] to calming or classical genres [18]. The genre of music may impact a driver's focus and concentration, with some studies suggesting that genres with high energy (e.g., Balkan folk or metal) led to faster driving speeds [17], while natural sounds or classical music were found to improve concentration and reduce stress [18]. These findings suggest that music genres can either enhance or hinder driver focus, depending on individual preferences and the characteristics of the music. This effect is further complicated by the interaction between tempo and genre, as some genres inherently feature faster tempos, which may exacerbate the effect of tempo on driving behavior. The Impact Of Participant Selection on Findings.

A notable decision in many studies was the participant selection, with a majority of studies involving young adults, particularly undergraduates with limited real-world driving experience. For example, studies by Unal [19], Babic [17], and Karageorghis [18] all had young adult populations, with a significant percentage of male participants.

This demographic is often more likely to engage in riskier driving behaviors and may respond differently to music compared to older or more experienced drivers. This participant selection bias could influence the generalizability of the results, as younger drivers may have different thresholds for arousal or stress compared to older individuals with more experience. Additionally, many studies (such as those by Karageorghis, [9,20]) only included male or predominantly male participants, which raises concerns about the applicability of findings to a broader, more diverse driving population.

7. DISCUSSION

The aim of this study was to systematically review and summarize the current published literature on the impact of listening to music whilst driving. The review included 17 experimental studies and one systematic review. Our findings suggest that music can have both positive and negative effects on driving performance, and these effects are influenced by a range of variables,including music tempo, genre, and individual differences.

7.1 Summary of Key Findings from the Review

Our review supports the initial hypothesis that music affects driving behavior, although the impact varies depending on the type of music and the individual listening to it. Specifically, high-tempo music was consistently associated with increased levels of distraction, arousal, and aggressive driving behaviors. For instance, studies by Navarro [16] and Karageorghis [9] found that faster music tempos elevated heart rate and arousal, leading to faster driving speeds and more risk-taking behaviors. On the other hand, slow-tempo music appeared to have a calming effect, which reduced aggressive driving and improved concentration [7,9].

In terms of genre, the effects were more variable, but certain genres, particularly those associated with higher energy levels such as rock and heavy metal, were linked to faster driving and less cautious behavior [17]. These findings support our initial hypothesis that music genres would impact attention and safety, although individual preferences and the context in which the music is played play a significant role. For example, some drivers may experience a greater positive effect from calming genres, like classical music, while others may find higher-energy genres more stimulating but potentially more distracting [18].

The hypothesis regarding aggressive driving and reduced attention levels when listening to high-tempo music appears to be supported by the findings in the reviewed literature. However, the hypothesis that *no music* results in safer driving (by being more focused and less aggressive) was less conclusive, with studies showing mixed results. Some studies reported that driving without music led to increased mental fatigue and stress [19], while others found no significant difference in driver attention or behavior between music and no music conditions [8]. These inconsistencies highlight the complexity of the relationship between music and driving behavior, suggesting that other factors such as the driving environment and individual differences may play a crucial role.

7.1.1 Impact of drivers age on conclusion

One key factor that must be considered when drawing inferences from the study findings is the potential impact of the age and driving experience of the participants. A significant proportion of the studies included in this review (e.g., Karageorghis, 2021; Babic, 2021) focused on young adults, particularly undergraduates with limited driving experience. This demographic is more prone to risk-taking behavior and may respond differently to music compared to older or more experienced drivers (Clarke, 2006). The high frequency of accidents in this age group—often attributed to inexperience, impulsivity, and higher levels of distraction—suggests that young drivers are particularly vulnerable to the negative effects of music, especially high-tempo and loud music.The limited driving experience of many participants in the reviewed studies may partially explain the observed increases in aggressive driving and risky behavior associated with certain music types. However, the fact that young drivers are often overrepresented in crash statistics underscores the importance of targeting this group with strategies to reduce driving-related accidents. This suggests that the recommendations in this review could be particularly important for younger drivers, as they may be more affected by music and its impact on their driving behavior.

7.1.2 Impact of Researcher vs Self-Selected MusicChoice

A significant consideration in the studies reviewed is the distinction between researcher-selected music and self-selected music. Many studies involved the researchers selecting the music for participants, which introduces a potential for bias in how reflective the results are of actual driving . Music is inherently a personal experience, and selecting it for participants may not reflect their preferences or individual emotional states. This lack of personal choice may limit the ecological validity of these studies, as it does not replicate real-world driving situations where drivers typically choose their own music. For example, studies have demonstrated that listening to preferred music can improve performance on cognitive tasks, enhance mood, and reduce anxiety (Cassidy, G., & Macdonald, R. (2009).

Furthermore, there is evidence from health-related studies that the self-selection of music plays a role in reducing stress and promoting well-being. Music that aligns with individual preferences has been shown to lower heart rates, decrease anxiety, and improve overall emotional states (Batt-Rawden, 2010). These benefits, when applied to driving, could help drivers stay calm, focused, and more aware of their surroundings, potentially improving road safety. Given these findings, it is clear that self-selected music may have a more beneficial impact on driving performance than researcher-selected music. Future studies should consider allowing participants to choose their own music in order to better reflect real-world conditions and provide a more accurate assessment of music's effects on driving behavior.

8. Recommendations

Based on the data presented in the papers included in this review, we recommend that drivers be mindful of the genre, tempo, and overall suitability of music that they select while driving. Previous research indicates that certain types of music, particularly those with fast tempos or high emotional intensity, can increase arousal and distract drivers, potentially impairing theirattention and reaction times.

On the other hand, slower, instrumental music tends to have a calming effect, promoting focus and reducing the likelihood of cognitive overload. To minimize hazards and maximize attention on the road, it is crucial that drivers select music that supports a balanced and alert state of mind. These recommendations can be incorporated into awareness campaigns aimed at undergraduates and young drivers, including targeted advertising, educational leaflets, and interactive courses that highlight the importance of mindful driving habits. Such initiatives can help foster safer driving environments by enhancing drivers' understanding of the impact of music on their behaviorand decision-making.

9. Strengths and Limitations

9.1 About Systematic Review as a Method

The merits of the systematic review research method used in this study are that it provides a broad overview of the field and enables us to present a clearer picture of existing knowledge. Furthermore, systematic reviews highlight key areas of interest, guiding future research efforts and identifying directions for replication in subsequent studies. Using established and systematic techniques we can review and summarize the existing work in the field and provide abackground for future experimental research.

However, there are notable limitations to consider. One limitation is the scope of what can be reported since it will be confined to studies included in the review criteria; hence, all relevant studies may possibly not be included in the review. As systematic reviews are focused on existing published literature, they may fail to identify new areas or new concepts which are becoming important in a particular field. The review processes might thus miss important developments.
Finally, the inherent biases of researchers—stemming from their individual experiences, perspectives, and preconceptions—can influence the review process, affecting the objectivity and interpretation of the findings presented.

9.2 About the Data from the Studies

The data reported from the studies reveals several strengths and limitations that are crucial to consider when interpreting the results. One of the primary strengths of the included studies is the utilization of driving simulators. Driving simulators allow for a safe environment in which to conduct such research. Both safety among the participants and the replicability of the experimental conditions would be improved using driving simulators. The use of simulators can be beneficial as they enable researchers to score driving performance objectively, to give insight into driver behavior safely, which may be hard to capture under real-world settings. However, a concern is that many projects employing driving simulators may lack ecological validity. The behaviors observed in such a setting may not accurately reflect individuals' behaviors in actual driving scenarios. Thus, the findings may not be able to be extrapolated to actual,real-world driving settings.

Another limitation is that some studies' findings are based on self-reported measures. These measures have validity problems, especially as participants may amend their answers due to social desirability bias. Due to this bias respondents often tend to have a strong need to portray themselves favorably, which can cause distorted reporting. This instinctive tendency to conform may lead to the over-reporting or under-reporting of actual driving behavior or attitude,particularly in behaviors viewed to be negative.

The personal aspect of music preference creates more complexity in the interpretation of study findings. Music

preference can vary greatly from person to person, and individuals often have specific tastes that can change over time. This variability can impact how participants engage with music in driving contexts, adding a further layer of complexity to the analysis ofresults.

10. Future Research

It is important to study the effect of alcohol on performance in the skills of driving with different musical conditions associated with it because alcohol impairs judgment and reaction time, increasing the risk of accidents. Understanding these factors can help reduce road safety hazards. Thereby, comparing the effects of the different types of music groups—specifically differences in tempo, genre, and volume—provide information as to how these particular factors affect the mental load and actual behavior at the wheel. Another important area could be how the presence of lyrics influences driving performance. Findings from a study by Brattico et al [24] on the impact of music with lyrics versus instrumental tracks found that the presence of lyrics in music evoked stronger emotional responses, however, the impact of this emotional change on driver behavior is understudied. Future research can seek to establish how the presence of lyrics can affect driver focus and the cognitive demands of driving, that may ultimately impact risk of automobile accidents. In this way, it may encourage more safe practices of driving among youngadults.

Another consideration for future work in this area is the replication of findings from driving simulation-based studies into real-world driving situations. Although driving simulators offer a controlled environment to evaluate the impact of music conditions, they lack ecological validity. Attempting to see if the effects of different music types remain consistent in real-world situations will allow for a better understanding of how music affects behavior in real life driving situations.

Lastly, the data on music usage during real driving incidents could provide good insights on music consumption in relation to alcohol consumption androad safety.

11. Conclusion

A key finding from this review is that the tempo of music plays a significant role in its potential to distract or enhance driving. High-tempo music has been shown in several studies to increase arousal felt during driving which may lead to reduced attention and increased impulsivity in driving behavior. These changes in attention and behavior may potentially compromise the safety of drivers. As a result, it is recommended that drivers avoid fast tempo and high energy music while beyond the wheel in specific situations that require heightened concentrations such as heavy traffic or unfamiliar routes.

It is important to note that the effect of music also varies depending on the driver. Factors such as age, driving experience, and gender have been suggested as influences on how music impacts driving performance. For instance, younger or less experienced drivers may be more susceptible to distraction, while experienced drivers may be less affected by the potential distraction of music. This variability calls for more nuanced research in the future to explore how different types of music interact with different driver profiles using sub-group analysis of participants.

In conclusion, the findings from this review indicate that the impact of listening to music on driver behavior and attention are influenced by both the type of music and the individual characteristics of the driver. The relationship between music and driving performance is complex as different music genres can evoke various emotional and cognitive responses that impact a driver's focus and behavior on the road.

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Appendix:

Table 2: Overview of Included Studies

Lead Author	Date of Publication	Reference Number	Number of Participants	Age in Years (mean)	Gender (% male)	DrivingType	Study Design	Measure ofDriving	Key Findings	Music Included
Unal	2012	19	69	Under graduates	33	Simulated	Cross sectional	Objectivemeasure	Performance unaffected by music tempo, but increased mental effort when music was loud.	Broad range(participants selected their own songs)
Zwaag	2013	25	28	21	50	Simulated	Cross sectional	Objectivemeasure	Abrupt music change calmed drivers and improved performance in high-demand drivingsituations	Calming (abrupt change)
Alves	2019	14	5	No data	0	Real world	Cross sectional	Researcherrating	Music may reduce stress (cardiac autonomic overload) during driving in high-stress conditions	N/A

Babic	2021	17	61	25	72	Simulated	Cross sectional	Researcherrating	Participants drove fastest with Balkan folk and metal music, while other music and no music resulted in slower speeds.	Various (e.g., Balkan Folk, Metal)
Beh	1999	26	45	Under graduates	88	Simulated	Cross sectional	Objectivemeasure	Moderate music improves performance requiring broad attention; loud music impairs performance	Moderate/ Loud
Brodsky	2002	8	20	33	30	Simulated	Cross sectional	Researcherrated	Music tempo increased driving speed and speed estimates	Slow,medium andfast
Brodksy	2018	11	29	Under graduates	32	Simulated	Cross sectional	Objectivemeasure	No significant findings on aggression or mood; focused on music's secondary-task effect (singing)	Various (Genres & Tempos)

Karageorghis	2021	9	27	21	100	Simulated	Repeated measures	Self-rated & objective measure	Slow-tempo music improved mood, reduced braking, and traffic noise increased mental demand.	Fast, Slow and an urban traffic-noisecontrol.
Navarro	2018	16	24	23	54	Simulated	Independen t measures	Researcherrated	Faster music tempos lead to higher arousal levels and better driving behavior.	Fast, slow andmedium
Stantoso	2013	27	60	30	100	Simulated	Cross sectional	Researcherrated	Increased driver safety with secure income and reduced music-related speeding in young drivers	Various
Niu	2020	28	36	23.6	68	Simulated	Cross sectional	Objectivemeasure	Music style and tempo affect driving performance, especially based on personality	Various (Tempo &Style)

Karageorghis	2022	20	46	29.8	50	Simulated	Mixeddesign	Self-rated, researcherrated &	Participants exhibited more risky behaviors in responseto fast-tempo	High,low and nomusic

								objectivemeasure	music. Drivers should exercise caution in their use of up-tempo music in urban settings.	
Fakerhusseni	2019	29	52	21.82	83	Simulated	Cross sectional	Self-rated	Results showed that angry drivers who did not listen to music had riskier driving behavior than emotion-neutral drivers.	N/A
Brodsky	2024	30	36	25	42	Simulated	Cross sectional	Self-rated & researcher rated	Music had no effect on situational awareness but may influence response selection and execution.	N/A

Dibben	2007	15	1780	No data	55	Real-world	Cross sectional	Self-rated	Music improves concentration but can distract younger drivers who prefer fast-paced genres	Various (Genres)
Fairclough	2014	31	100	21.2	50	Simulated	Independen measures	Self-rated,resea rcher rated & objective measures	Low-activation music reduces cardiovascular reactivity, no effect on self-reported mood	Various
Febriandirza	2017	18	98	24.47	50	Simulated	Cross sectional	Objective measures	Natural sounds led to better control, concentration, and enjoyment compared to hard rock music	Hard Rock, Classical, Natural Sounds
Ghojazadeh	2023	7	Systematic review	N/A	N/A	N/A	Meta analysis	N/A	High-volume music increases speed and decreases heart rate, low-volume has opposite effects	N/A