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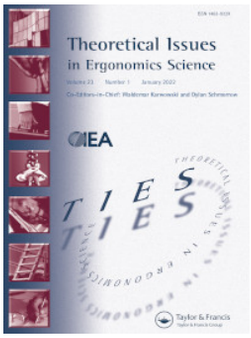

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Influence of music on driver psychology and safety-relevant behaviours: a multi-study inductive content analysis

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ABSTRACT

Underpinned by pragmatism and symbolic interactionism, an inductive content analysis was conducted to assess driving experiences under a variety of music conditions. Many quantitative studies have addressed the effects of music on drivers, but there has been a conspicuous dearth of qualitative research to provide a more nuanced understanding of music-related phenomena. Data collection took place over three simulated driving studies, each with different tasks/participants (Study 1 – $n = 34$, Study 2 – $n = 46$, and Study 3 – $n = 27$). The inductive content analysis was conducted by two members of the research team and a peer debriefing was conducted by a third. Findings show that music can have a range of affective, behavioural and cognitive effects (both positive and negative), that are moderated by the driving environment (i.e. urban vs. highway) and aspects of the musical stimulus (i.e. inclusion/non-inclusion of lyrics, loudness and tempo). Participants were mindful of the implications of in-vehicle music vis-à-vis the safety–performance–pleasure trade-off. The analysis suggested a perceived beneficial effect of music and consequent contribution to driving style/safety-related performance. Younger drivers' apparent reliance on music as a means by which to regulate their emotion highlights an education need in terms of optimising selections.

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Distraction; emotion; pragmatism; qualitative; symbolic interactionism

Relevance to Human Factors

Despite burgeoning interest from a positivistic perspective on how in-vehicle music affects drivers, there has been a noticeable dearth of comparable interpretivistic work. This report draws on data from three simulator studies and applies inductive content analysis to facilitate a detailed and nuanced understanding of the music–driving nexus.

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Supplemental data for this article are available online at https://doi.org/10.1080/1463922X.2021.2009933.
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Introduction

Since the late 1950s when sound systems were 'fitted as standard' into automobiles, listening to music is an activity that drivers have engaged in habitually (Brodsky 2015). Many drivers feel that music alleviates boredom and keeps them suitably focused – particularly on longer drives. Others know instinctively that there are times the music should be turned down (or off) but they continue regardless. The debate of *what* to listen to at the wheel has raged for decades, and recommendations vary depending on whose scientific work is consulted (Millet, Ahn, and Chattah 2019).

The sound of blaring rock anthems punctuated by wailing guitar solos perhaps represents an archetypal notion of what to listen to on the open road. A notion spawned by rock 'n' roll culture, a concomitant of the democratisation of car ownership witnessed in 1950s America (Brodsky 2015). Latterly, young urbanites the world over have espoused the genres of hip hop and R&B;[1] car windows are often lowered to give entire neighbourhoods a taste of pronounced basslines and machine-gun style lyrics (Brodsky and Slor 2013). Males, in particular, are known to use music as a proxy for their masculinity and to show others the subculture to which they subscribe (North and Hargreaves 2008).

Leaving such stereotypes aside, streaming data show that a vast array of music is used by drivers, and research data provide some insight as to how drivers make functional choices (Brodsky 2021; Dibben and Williamson 2007). For example, up-tempo tracks of a stimulative nature can engender optimal psychomotor arousal for the vigilance required during intercity drives (Navarro et al. 2019). Contrastingly, the multiple cognitive demands and mental stresses that characterise urban environments, lead drivers to more soothing selections (Brodsky 2021). In short, music has the propensity to optimise a driver's mental state and thus improve both their concentration and vehicular control (Karageorghis et al. 2021a).

Insurance company and police records illustrate how young drivers are at particular risk – to themselves and to other road users – when their music choices are less than optimal (i.e. loud/aggressive music; Brodsky, Olivieri, and Chekaluk 2018; Dibben and Williamson 2007). Sophisticated conceptual frameworks pertaining to driving behaviour, such as Fuller's (2011) Driver Control Theory, place considerable emphasis on the mismatch between young/inexperienced drivers' *perception* of their driving abilities and their *actual* driving abilities. The mismatch leads to what is often shown in police accident reports. Essentially, at the scene of many crashes, police encounter the blare of aggressive forms of music (e.g. gangsta rap or heavy metal) and such music has been shown to result in higher cruising speeds and a higher percentage of time in excess of the speed limit (Brodsky, Olivieri, and Chekaluk 2018). The present study has a particular focus on young and inexperienced drivers, with a group of middle-aged drivers sampled for comparative purposes.

Empirical research into music and driving

There has been a plethora of quantitative studies into music and driving behaviour in recent decades (for reviews see Brodsky 2015; Millet, Ahn, and Chattah 2019). Such work has shown that in-vehicle music can mask critical sounds (e.g. upcoming vehicles; Ho and Spence 2009) and lead to speeding or reckless manoeuvring (Brodsky 2001; Dalton et al. 2007), particularly so when the music is energising and at a high sound intensity (e.g. Dibben and Williamson 2007; Ünal et al. 2013a, 2013b). It is recognised, however, that music with different

psycho-acoustic properties is required for different environments (e.g. urban vs. rural) and driving conditions (wet vs. dry; see Millet, Ahn, and Chattah 2019 for an overview).

The corpus of work has shown that there are several benefits associated with vehicular music use. Most prominent among these involves music's ability to engender a suitable level of activation in a driver during a long-duration drive that is likely to induce mental fatigue (Dibben and Williamson 2007; Ünal et al. 2013a). Another benefit that has been identified in a number of studies is that soft/gentle music can improve safety in car-following type tasks (i.e. there is superior distance observance; Navarro, Osiurak, and Reynaud 2018; Oron-Gilad et al. 2008; Ünal et al. 2013b). Moreover, music can relieve boredom and enhance a driver's affective state (Karageorghis et al. 2021b; Sachs et al. 2020; van der Zwaag et al. 2012).

A leading scholar in this area of research is Warren Brodsky (Ben-Gurion University of the Negev, Israel) who, through an enduring and systematic body of work, has shone a bright light on the specificities of music application in the realm of driving (see, e.g. Brodsky 2018; Brodsky 2021; Brodsky and Kizner 2012; Brodsky and Slor 2013). Brodsky's programme of work started by examining fundamental questions regarding music use and risk-related issues such as inattention (Brodsky 2001). The programme rapidly evolved to consider how the mood-regulating qualities of music might be harnessed by drivers (see Brodsky 2015, for an overview).

Brodsky and Kizner (2012) examined how music programmes might be optimised for safety-relevant behaviour on the road. They argued that the abuse of music can be hazardous and suggested that easy-listening music might be considered for safety purposes. Specifically, Brodsky and Kizner considered tracks that attenuate medium-quality tone frequencies, instrumental ranges, arrangements, voicing textures, tempos, intensities and rhythmic activity. Moreover, their music programmes were devoid of memorable melodic lines that might serve as a distraction. Most recently, Brodsky (2021) conducted a survey-based study with young drivers, which showed that playlists are pre-planned based on anticipated driving conditions and that music is widely used for mood regulation.

Rationale and purpose of the present study

With the exception of a few qualitative music-related studies in which driving was not the central focus (e.g. Garrido and Schubert 2011; Hu, Chen, and Wang 2021), there is a conspicuous dearth of qualitative studies. Specific advantages afforded by a qualitative approach in this domain include: (a) the ability to focus on subjective, cultural aspects of the music-and-driving experience; (b) providing insight into drivers' music-selection decisions under a variety of driving contexts; and (c) furthering understanding of risk from a driver perspective. Given the lack of such work to facilitate a deep and nuanced understanding of the effects of in-vehicle music listening on drivers' psychology and behaviours, the present study sought to fill a gap in the knowledge base. We used simulated driving tasks with music as a precursor to administering a series of open-ended questions to participants. To be able to apply the findings to a broad range of driving scenarios and music applications, three contrasting approaches were used.

Our epistemological approach was underpinned by pragmatism and symbolic interactionism. The pragmatist position rejects the assumption of an objective reality and recognises that researchers will, invariably, carry certain preconceptions about the topic under investigation (Bryant 2009). In this instance, the authors had conducted a series of related

studies using a variety of quantitative approaches. This body of nomothetic work illustrated both facilitative and debilitative effects of music in the driving context, depending on music selection, sound intensity, individual difference factors and the type of driving task under investigation. Inductive content analysis entails deriving concepts from the data. This is entirely different to deductive content analysis, wherein the structure of analysis is operationalised on the basis of previous knowledge or theory (Hsieh and Shannon 2005; Schreier 2012). The former approach was used in the present study given the disparities and multiple moderators identified in the extant body of nomothetic work (see, e.g. Millet, Ahn, and Chattah 2019).

A core aspect of symbolic interactionism is that the meanings people ascribe to given phenomena are modifiable and open to reappraisal based on social interaction (Blumer 1969); a key evolutionary function of music has been to facilitate such interaction (Levitin 2007). The predominant focus of our study was on young drivers, particularly young males who are over-represented in UK road crash statistics (Department for Transport 2020), but young females and middle-aged participants of both sexes were also included. The overarching purpose of the present study was to use inductive content analysis on responses to open-ended questions that followed three distinct simulated driving studies, each with an independent sample. Given the inductive nature of the study, no a priori hypotheses were set.

Methods

Participants

Volunteer participants were recruited from three related (quantitative) studies that examined various psychological, psychophysiological and behavioural responses to music in a driving simulation protocol. In Study 1, there were 34 adults with 17 women and 17 men (M_{age} = 22.2 years, SD = 2.0 years; Karageorghis et al. 2021b). In Study 2, there were 46 adults with 23 women and 23 men (M_{age} = 29.8 years, SD = 2.0 years; Karageorghis et al. 2021c). Of these, 24 were young adults (M_{age} = 21.7 years, SD = 2.2 years) and 22 were middle-aged adults (M_{age} = 38.6 years, SD = 3.7 years). In Study 3, there were 27 young male adults (M_{age} = 20.6 years, SD = 1.9 years; Karageorghis et al. 2021a). Participants reported good health, a lack of motion sickness in immersive video games, no hearing or visual impairment, and held a UK driver's licence. Participants provided informed consent and the study complied with the American Psychological Association Code of Ethics.

Data collection

The qualitative data collection took place immediately at the end of the simulated driving task in each of the aforementioned studies (full details of the driving simulator are contained in Supplementary Online Material 1). The task in Study 1 was an 8-min simulated urban driving task under six conditions: (a) loud (75 dBA), lyrical music; (b) loud, non-lyrical music; (c) soft (60 dBA), lyrical music; (d) soft, non-lyrical music; (e) urban traffic noise control; and (f) spoken lyrics. The task in Study 2 was an 8-min simulated driving task in an urban and highway environment. For each environment, there were three conditions: (a) fast-tempo music (130–140 bpm); (b) slow-tempo music (60–70 bpm); and (c) an urban

traffic-noise control. The task in Study 3 was an 8-min simulated urban driving task under four conditions: (a) participant-selected fast-tempo music (130–140 bpm); (b) participant-selected slow-tempo music (60–70 bpm); (c) researcher-selected music (90–100 bpm); and (d) an urban traffic-noise control. In each study, a wordsearch task was used as a 'filler' in between trials.

The post-experiment questionnaire consisted of 11 open-ended questions pertaining to participants' experience in the driving simulator study and their in-vehicle music-listening habits in real life. The following four questions were used for the inductive content analysis, as they directly addressed the potential effects of music during driving:

- Q1: *Prior to this study, had you ever used music to influence your emotional state while driving in an urban environment and, if so, how exactly?*
- Q2: *Has listening to music during an urban driving simulation changed your perception of the experience in any way and, if so, how?*
- Q3: *Would listening to music during real urban driving make you likely to drive more safely in the future?*
- Q4: *What aspects of your emotions or behaviour during real urban driving is music likely to change?*

The researcher afforded participants an opportunity to seek clarification in relation to the four questions. Note that seven of the questions were not used for the present study because they were directed towards participants' experience of the driving simulator (i.e. realism, simulator sickness and general feedback) as well as perceived differences across driving scenarios, rather than the effect of music during driving per se.

Analytical strategy

Inductive content analysis is a systematic method that aims to describe the meaning of qualitative data (Hsieh and Shannon 2005; Schreier 2012). It applies the process of abstraction to reduce and group data so that research questions can be flexibly addressed by use of concepts and/or themes. Having chosen a unit of analysis, the researcher goes through the textual data to identify open codes. These are then combined with other open codes that include similar content to form sub-concepts or sub-themes. The sub-themes are then combined into concepts or themes, which are further organised into main or second-order concepts/themes. In accord with the Straussian approach, the researchers' knowledge of the subject matter was brought to bear in the analysis (Corbin and Strauss 2015).

Given that inductive content analysis is 'data-sensitive', the two researchers who conducted the coding returned to the original data repeatedly during the iterative and analytical process to ensure that the results were strongly connected to the data that they analysed. Thereafter, a peer debriefing was conducted by the first author to ensure the trustworthiness of the analysis. The context of the research was taken into consideration to determine the meaning of the responses and interpret them when necessary. The researchers tested the consistency (i.e. no overlapping between categories) and validity (i.e. the extent to which the categories describe the material) of the coding frame by a trial coding. After a few adjustments were made, the final-version coding frame was used for analysis.

Results

The first section presents frequencies of *yes* and *no* answers in response to the closed questions, whereas the ensuing sections present the inductive content analysis, starting with the raw data themes, then the first-order themes followed by the second-order themes, and finally, the general dimensions. A total of three instances of participants not answering a question (i.e. missing data) were identified.

Responses to closed questions

The percentage of *yes* and *no* responses for each question that elicited a closed response is summarised in Table 1. The column *Occasionally* includes answers such as *yes, but not always* whereas the column *Conditionally* includes answers such as *yes, but it depends on the traffic condition/volume of music*. Question 4 is not a closed question and so does not appear in Table 1.

Raw data

A total of 425 transcripts were extracted from the interviews, including 107 transcripts for Question 1,105 transcripts for Question 2, 106 transcripts for Question 3 and 107 transcripts for Question 4. Similar transcripts were merged to form a total of 82 raw data themes. Table 2 shows the raw data classified into raw data themes, first-order themes, second-order themes and dimensions.

Two transcripts were not related to any of these themes and were excluded from the analysis, as they were not deemed relevant in terms of the questions posed. These transcripts mentioned the experience in the simulator ('made the simulator feel more realistic' and the 'strange feeling of being in the simulator'). Data saturation was achieved early in the processing of the Study 3 data but this study provided additional subtleties and examples.

First-order themes

The raw data themes were examined to identify those directly related to the use of in-vehicle music. Those not related were removed from the analysis. Thereafter, one or more first-order themes were extracted for each quote, leading to the compilation of 25 first-order themes (see Table 2). These first-order themes were related to feelings (e.g. *calm*, *aggression* and *tension*), mental processes (e.g. *concentration*, *distraction* and *hazard perception*) and vehicular control (e.g. *speed management*, *increased speed* and *driving control*).

Table 1. Proportion of 'Yes' and 'No' answers for each question (frequencies indicated in parentheses).

	N	Yes	No	Occasionally	Conditionally
Q1	107	76% (81)	13% (14)	6% (6)	6% (6)
Q2	105	71% (75)	27% (28)	0% (0)	2% (2)
Q3	106	47% (50)	25% (27)	14% (15)	13% (14)

Note. Q = question. Q1 was about using music to influence emotional state. Q2 was about using music to change perception of the driving experience. Q3 was about using music to drive more safely.

Second-order themes

The first-order themes were combined into nine second-order themes that matched in terms of conceptual relevance (see Table 2). These second-order themes referred mostly to the positive ('makes me more positive and forget about my worries') and negative ('makes me want to drive faster') effects of music on drivers. Neutral effects of music were also reported but in fewer instances ('music changes my mood' or 'music has an impact on my driving quality'). These neutral second-order themes were not included in the analysis.

Table 2. Results of the inductive content analysis.

Raw data themes ($k = 82$)	First-order themes ($k = 22$)	Second-order themes ($k = 8$)	General dimensions ($k = 3$)
Maintaining concentration on the road Keeps me alert Paying more attention with certain music More focused Thinking clearer in general	Concentration	Attentional focus	Cognition
Can get carried away in the music Can make my mind wander Less distracted by my thoughts Stops me from zoning out	Distraction		
I couldn't hear the traffic as well It can mute the environment	Environmental stimuli	Awareness	
I'm more aware of my surroundings I'm better able to see things coming I might not see a hazard coming	Hazard perception		
Can make me more frustrated Annoyed by slower drivers more easily I had less road rage Loud music can make me more aggressive Music stops me from lashing out Without music, I am more irritable towards others	Aggression	Anxiety	Affective state
Can make me feel uneasy Helps me feel calm rather than nervous I was not as jumpy Less likely to cause panic Reduces anxiety Faster music made me a little more impatient	Tension		

(*continued*)

Table 2. continued

Raw data themes ($k = 82$)	First-order themes ($k = 25$)	Second-order themes ($k = 8$)	General dimensions ($k = 3$)
It made me feel less sleepy Music can make me drowsy The music helped to prevent fatigue Without music I tire faster	Fatigue	Lethargy	Affective state *(continues)*
Makes me feel down and depressed Slower songs make me feel more down	Sadness		
Slow music made me over-relaxed Less switched on	Sluggish		
Keeps me entertained More positive and forgot about my worries Makes the experience more fun Music makes me feel happy Puts me in a good mood Music adds to the enjoyment of driving Uplifts the mood Music can change my mood immediately	Cheerfulness	Energised *(continues)*	
Helps to relieve boredom Influences my emotional state Less monotonous Maintain a healthier spirit Makes the experience more enjoyable Passes the time quicker	Enthusiasm		

Table 2. continued

Raw data themes ($k = 82$)	First-order themes ($k = 25$)	Second-order themes ($k = 8$)	General dimensions ($k = 3$)
I feel energised with music Made me feel overconfident Makes me feel excited Music engages my mind Stimulates the brain	Excitement	Energised	Affective state
Changes my mindset and imagination Driving with more confidence Keeps me interested in driving More refreshing	Positive mindset		
Improves my patience when I drive More composed Stops me getting over-excited I find it calming	Calmness	Relaxation	
Gentle music helps reduce my stress levels Music released tension The music made me more relaxed	Stress relief		
I didn't notice when I was speeding Makes me want to drive faster	Increased speed	Driving negative	Driving behaviour *(continues)*
I found myself overtaking more often Makes you drive faster and more dangerously Fast music made me more aggressive/ reckless	Risk-taking		
Made more mistakes Makes your driving more unsafe	Reduced safety		

Table 2. continued

Raw data themes ($k = 82$)	First-order themes ($k = 25$)	Second-order themes ($k = 8$)	General dimensions ($k = 3$)
Leads to more rational decisions Speed up my reaction to sudden hazards	Decision making	Driving positive	Driving behaviour
I feel more comfortable listening to music Makes my driving more accurate Stops me from driving erratically Better fuel economy when I listen to slow music	Driving control		
Affected how cautiously I drove More courteous With music I drive safer	Safer driving		
Classical music helps me stick to speed limits Driving slower	Speed management		

The first set of second-order themes elicited by the participants was *attentional focus* and *awareness*. *Attentional focus* referred to the effect of music on drivers' physiological state in terms of concentration or distraction ('more focused'), whereas *awareness* referred to the comprehension of the driving environment while listening to music ('more aware of my surroundings'). *Attentional focus* evokes internal processes ('I could not hear the traffic as well'), whereas *awareness* evokes external processes ('helps me stay concentrated on the road'). These second-order themes related to aspects that might be modulated either positively ('feel energised with music') or negatively ('I might not see a hazard coming') by musical stimuli.

Participants mentioned that different moods, feelings and emotions could be triggered by in-vehicle music. These second-order themes were labelled *anxiety* ('music stops me from lashing out') and *depression* ('slower songs make me feel more down'). Moreover, a number of second-order themes referred to the effect of music on drivers' arousal in terms of excitement ('makes me feel excited'), enthusiasm ('less monotonous') or merriness ('music makes me more positive and forget about my worries'). This set of themes was labelled *energised*. Somewhat complementary to *energised,* the *relaxation* second-order theme encapsulated two degrees of physical and emotional tension, calm ('improves my patience when I drive') and relaxed ('the music made me more relaxed').

The following set of second-order themes emerged in parallel and were differentiated based on the positive or negative outcome of listening to music on the operation of the vehicle. These two themes were labelled *driving negative* and *driving positive*. Most commonly, participants passed comments that were either negative (e.g. 'I became more aggressive or reckless') or positive (e.g. 'I made more rational decisions').

General dimensions

The nine second-level themes were paired according to their conceptual relevance, and then categorised under one broader theme (see Table 2). As a result, three different dimensions emerged from the corpus of responses to the four post-experiment questions. They were labelled *cognition*, *affective state* and *driving behaviour*. With reference to *cognition*, participants commented on their mental resources and state while driving and listening to music. This dimension is composed of the first-order themes *attentional focus* and *awareness*. In general, participants declared that music supported concentration ('keeps me alert'). Conversely, participants highlighted that music led to reducing the attention paid to the environment ('I might not see a hazard coming') and also missing environmental cues ('it can mute the environment').

With respect to *affective state*, drivers indicated that they could be affected by musically-induced moods, feelings and perceived tension during a journey. On occasion, music could help regulate their general mood or specific emotions. For instance, some participants indicated that music 'puts me in a good mood'. Music also seemed to moderate the stress generated by demanding situations, as illustrated by the quote 'the music made me more relaxed' or 'music released tension'. *Energised*, *relaxation*, *anxiety* and *depression* are the components of the *affective state* dimension.

In terms of *driving behaviour*, it transpired that music led to behavioural responses in terms of the operation of the vehicle. More specifically, participants commented that in-vehicle music affected the manner in which they drive in terms of safety ('with music I drive safer'), better performance ('makes my driving more accurate') and comfort ('I feel more comfortable listening to music'). A number of quotes stressed how certain characteristics of music, such as volume or tempo, were more likely to influence the three dimensions positively or negatively. This was reflected in the following quotes: 'I can pay more attention with certain music', 'with faster music, I could be a little more impatient' and 'makes me want to drive faster'.

To summarise, about three quarters of the participants answered 'yes' to Q1 and Q2. Nearly half answered 'yes' in response to Q3, with almost a third adding that their 'yes' was

circumstantial. Based on 82 raw data themes, the inductive content analysis entailed the extraction of 25 first-order themes, which were then categorised into nine second-order themes that, in turn, fed into three general dimensions. These dimensions pertained to information processing, emotions and actions linked with listening to music while driving (see Table 2).

Discussion

The present study addressed an area of driving behavioural research that has been underserved, with the application of an interpretivist approach to examining the psychological and behavioural effects of music on drivers. The approach was supported by the use of simulated urban and highway driving tasks accompanied by a variety of relevant music programmes to provide participants with an immediate context in which to ground their responses. In the interpretation of the data, we adopted pragmatism and symbolic interactionism as our research paradigm. Pragmatism holds that there are multiple ways of interpreting the world (i.e. there is no objective reality; Bryant 2009) and a key assumption of symbolic interactionism is that individuals derive meaning from social interaction and such meaning is modified through interpretation (Blumer 1969). In accord with the authors' pragmatic approach (i.e. prior knowledge of the subject matter that they brought to bear), rich evidence emerged to suggest that music can both facilitate and debilitate driving performance (see Table 2).

Appraisal of the inductive content analysis

Participants in the three studies experienced the same combinations of environmental stimuli and demands, and accessed music presented in consistent formats (i.e. at a standardised sound intensity). The resultant participant responses were prompted by the immediate demands of the study and the simulated driving experience. Participants were also encouraged to draw upon their wider driving history and experience of consuming music through radio broadcast and self-generated or auto-generated playlists, both as individual vehicle occupants and within the wider social setting of the shared experience of driving with other passengers present. The wider social setting tessellated with the social interactionism framework that underpins the present investigation.

That music would affect emotional state in ways that influence driving behaviour is not a surprise (see Table 1), with established research showing psychological effects that would be likely to have a bearing on driving performance (see Brodsky 2015; Millet, Ahn, and Chattah 2019, for reviews). However, through a qualitative approach, the present study afforded an opportunity to capture nuanced data on the effects of music from participants who had just experienced specific music programmes in controlled driving tasks. The research paradigm we adopted did not entail the testing of a priori hypotheses; rather themes were derived via an inductive content analysis, characterised by three progressive levels of abstraction.

Our results showed that a significant majority of participants recognised music as a common accompaniment to driving that could induce moods, feelings and even very specific emotions (e.g. calmness or cheerfulness; see Table 2). This has implications for the domains of driver safety, performance and comfort (see, e.g. Dibben and Williamson 2007).

Responses indicated that specific musical qualities (such as volume and tempo) influenced the magnitude and direction of the effects in each domain (see Table 2). This finding aligns somewhat with the findings of Millet, Ahn, and Chattah's (2019) meta-analysis and their associated conceptual framework. The framework foregrounds the mediators of contextual factors (e.g. road type, traffic conditions), features of music (e.g. familiarity, instrumentation) and driver characteristics (e.g. gender, driving experience). As most of the present participants were relatively young, inexperienced drivers, the potential for music to compromise safety on the roads came to the fore in terms of the general dimension of driver behaviour (see Table 2).

From a driver safety perspective, Fuller's (2011) Driver Control Theory provides a prism through which our results can be contextualised. The theory posits that vehicle control represents a fine balance between the demands of the task and capability of the driver. If the task demands increase (e.g. through in-vehicle social interaction), the driver must adapt their driving style or risk the task demands exceeding their capability. Exceeding the capability threshold can result in an accident or, more often, a near miss. Our participants tended to report that, either positively or negatively, music influenced their capability. In critical situations, the presence (or absence) of music with specific characteristics might be the difference between loss of control or staying on the road (Brodsky, Olivieri, and Chekaluk 2018).

Millet, Ahn, and Chattah's (2019) conceptual model details how listening to music elicits physiological and psychological responses in drivers that result in changes in driving outcomes (e.g. response time, lateral control and traffic signal violations). Nonetheless, in view of the variation in participants' responses in the present study, the model does not elucidate the interplay among music features, contextual factors and driver characteristics. Such interplay has been brought into sharp focus through application of an interpretivist approach within a framework of pragmatism and symbolic interactionism; this is an original contribution of the present study.

The inductive content analysis has drawn upon a wide range of responses that are grouped into first- and second-order themes. These themes are derived bottom-up from the expressed experience of each participant. Accordingly, such expressions and themes are not weighted or directly compared for 'value' on a given parameter. Direct measures of driver behaviour (e.g. speed or lane keeping) or activation levels (e.g. as reflected in physiological measures) are not the focus of this study. This qualitative analysis of expressed introspections has revealed both how music is perceived as central to the driving experience and how participants feel their affective state and driving performance can be modulated (see Table 2). In a driving simulator study (Karageorghis et al. 2021b), drivers who were identified as being assertive perceived their performance to be 33% better with loud, lyrical music when compared to soft, lyrical music, despite not performing better in objective terms. This finding illustrates how there can be large discrepancies between drivers' perceptions of their performance and their actual performance.

Illustrative participant quotes

There is a strong assertion that music can make a journey more enjoyable and comfortable and that those same journeys without music can feel boring, tiring or even frustrating,

depending on the prevailing traffic situation (Brodsky 2015; Dibben and Williamson 2007). Fuller's (2011) model is supported insofar as there is a strong assumption that driving capability can be modulated and optimised by improving the affective state of the listener (levels of affective valence and arousal; Russell, Weiss, and Mendelsohn 1989). Typical comments (i.e. raw data themes) and the derived first-order themes are predominantly positive in nature. For example:

i. The majority of the time I have music while I drive, especially on the motorway. Music keeps me calm and helps me focus on myself and my car more. (Q1, 23-year-old male)
ii. Yes, playing upbeat and relatively loud music influences my driving positively. (Q1, 22-year-old female)
iii. What music can do in my opinion, is keep one calm and collected, when traffic jams get one frustrated, I find that calm music helps to keep temper in check, which can result in safer driving. (Q3, 20-year-old male)

There were far fewer expressions of awareness of music having a potentially negative effect and those that did emerge were focused on the propensity of music to distract from either the routine monitoring of the vehicle state (e.g. speed maintenance) or from outside traffic events (Ünal, Steg, and Epstude 2012). For example:

iv. I was aware beforehand that I tend to drive faster when listening to more energetic music. I get more engaged in it so not noticing speed is easier. (Q2, 20-year-old male)
v. I turn the music off if I am in an unknown area so I can concentrate. (Q3, 38-year-old female)

There was little acknowledgement that music could actively modulate driving style detrimentally or directly promote dangerous driving. Nor were there many expressions of the socialising force of music through reinforcement of notions of self-identity or of belonging to a particular group, with a few notable exceptions; for example:

vi. I use music to alleviate boredom or when I'm in the car with other people to get excited for something. (Q3, 20-year-old male)
vii. Motorway driving with no music makes me bored very quickly and I was then easily distracted. I found myself looking around more. (Q2, 41-year-old male)

As evidenced in government statistics (e.g. in the UK, Department for Transport 2020) or in reviews of younger driver safety performance (Helman, Grayson, and Parkes 2010; Orsi et al. 2013), we see that one of the strongest predictors of young driver safety performance and risk taking is a simple frequency count of the number of passengers in the vehicle. The more passengers of a similar age, the stronger the likelihood of unsafe driving behaviour (Dibben and Williamson 2007). Music, as illustrated in comment vi above, is likely to play a role in establishing and reinforcing attitudes and behaviour in certain combinations of journey purpose and traffic situation. Such nuanced effects of music are difficult to glean from the positivistic approach that typifies the music-in-driving literature (see, e.g. Millet, Ahn, and Chattah 2019).

Strengths and weaknesses

A significant strength of the present approach is that comments were derived immediately following a drive under controlled conditions (three studies, each with separate participants) with a broad range of traffic and speed conditions and exposure to a structured and standardised music programme. The first-order and second-order themes that have emerged show clearly the perception of the contribution of music to the affective and cognitive state of the driver. It adds to a burgeoning corpus of work that highlights the near ubiquity of music during the driving experience; particularly for younger drivers (e.g. Brodsky 2021; van der Zwaag et al. 2012). The themes also point to the multifaceted ways in which music can be used to promote safer driving behaviours (e.g. through providing a source of activation during long drives) and undermine safety (e.g. when fast/loud music causes speeding and/or recklessness), which illustrates the added value of the epistemological stance adopted herein.

The current study is limited by an open-ended questionnaire approach to collecting the data that did not permit a more detailed probing of individual participants (e.g. in terms of the relative importance of aspects of the in-vehicle music experience). In the present context, it was challenging to draw conceptual distinctions among the constructs of affect, mood and emotion given the interpretivistic nature of the investigation. In accord with the underlying framework of pragmatism and symbolic interactionism, such terms will, invariably, hold different meaning for different individuals. We refer the reader to Ekkekakis (2013) for a full discussion of these distinctions.

The use of music when driving is a particularly challenging area to regulate. The range of effects that music can have and the enjoyment that drivers gain from listening to it suggest that any attempt to impose strict regulations on the use of music while driving would be impracticable. Clearly, certain styles of music (e.g. aggressive music such as gangsta rap or heavy metal) have the potential to result in increased collision risk for certain drivers by inducing faster or more assertive driving styles (Brodsky, Olivieri, and Chekaluk 2018). However, easy-listening selections, and particularly instrumentals, can leave drivers feeling less stressed and more alert (Brodsky and Kizner 2012).

Recommendations for research and practice

Looking forward, there are some intriguing possibilities that emanate from the present findings. As we progress rapidly towards vehicles that offer greater levels of automation, it is likely that more sophisticated driver monitoring will ensue (Kyriakidis et al. 2019). Specifically, this will be a means by which to determine whether the driver is suitably alert to resume control should that become necessary (e.g. when a collision is imminent). If the monitoring system were able to detect a driver's affective state – perhaps via facial expression and/or blink rate – this could be used to offer a music playlist that would help to optimise their mental state with reference to driving safety, performance and focus. If the driver is using a navigation system, route information could be used to tailor the music type in a manner that suits the type of driving (highway vs. rural vs. urban driving) and the length of the route remaining.

Future studies could examine the influence of adaptive music selection to suit the type of driving and state of the driver and compare that to similar drives with no music, driver-selected music and a selection that is uniform in its characteristics. Such work might employ a mixed-methods approach to examine extended performance in a driving simulator (i.e. longer drives), allowing for greater exposure to music stimuli (i.e. entire playlists), providing more data for analysis (i.e. quantitative and qualitative) and increasing the likelihood that mistakes and fatigue might influence performance. Placing drivers in situations where the task demand nears their level of capability might better reveal the potential benefits or drawbacks associated with music use (cf. Fuller 2011). Moreover, it is important to extend this line of research to older adults, albeit a fulsome habituation procedure is needed to circumvent the common limitation of simulator sickness (see Sawada et al. 2020).

Several car manufacturers (e.g. BMW, Ford, Mercedes, Mini, Vauxhall) have offered speed-sensitive volume control via their in-vehicle entertainment systems for a number of years. As the speed of a vehicle increases, wind, engine, and tyre noise all increase (Felber 2011). There is a dearth of published research into how gradients in music volume that are concomitant with increasing vehicle speed influence the driver's attentional processing and affective state. The likelihood exists that such automated in-car systems might lead to a degree of attentional overload with attendant implications for road safety. The suggestion in the present findings (see Table 2) that, in certain instances, fast/loud music can lead to more reckless driving behaviours is something that warrants additional investigation.

The perceived benefits of music that drivers reported in the present study should not be accepted uncritically. They reflect drivers' impressions of the simulated driving task administered to them and should be duly scrutinised in light of the abundant literature on the topic. Such work illustrates how loud and aggressive music, in particular, can have negative consequences for the safety of road users (see, e.g. Brodsky 2015; Millet, Ahn, and Chattah 2019). Safety campaigns might draw attention to the discrepancies between drivers' impressions and observed behaviour in relation to music listening during driving. This could help people in better directing their driving capability to on-road demands, as highlighted in Fuller's (2011) Driver Control Theory.

Further research, both in controlled environments such as a driving simulator but also in naturalistic settings, where observations are made in-vehicle during real traffic driving, should also focus specifically on risk taking and potential shifts to thresholds for risk acceptance, as mediated by particular forms of music (Brodsky 2021). Moreover, it will be important to determine whether listening to specific types of music makes the occurrence of other forms of safety-relevant behaviour more likely. For example, is a driver who is likely to choose a particular type of music also more likely to access their social media accounts while driving?

Conclusions

Inductive content analysis is an informative methodological approach to adopt for the generation and subsequent interpretation of qualitative data. We adopted the approach as a means by which to minimise researcher bias in the ontological framework that was used. The overwhelming picture that emerged from the analysis of comments and derived themes is one of a perceived beneficial effect of music on the driving experience and consequent contribution to driving style and safety-related performance (see Table 2).

Participants across the three contributing studies acknowledged a tacit understanding of driving being a demanding activity and the possibility, even the advisability, of self-regulating affective state to optimise performance. There was also acknowledgement that different types of music may be more suitable for particular types of driving, though there were disparate views in terms of what constituted suitable music. There was very little reference to music influencing driving in a negative fashion (see Table 2). Some comments referred to potential distraction (i.e. a cognitive outcome) through the masking of exterior events or reduced monitoring of vehicle factors, such as speed. Participants showed little acknowledgment that louder, more energetic music could directly influence speed choice and engagement with other road users (e.g. car following distance and lane position).

While the potential benefits of music were widely acknowledged and promoted, potential disbenefits were not (see Table 2). Given the increasing corpus of evidence suggesting that some forms of music can have a contributing role to distraction, risk taking and traffic safety (Catalina et al. 2020; Ünal, Steg, and Epstude 2012), the role of novice training, driver regulation and vehicle technology should be reviewed with due urgency.

Note

1. "R&B" is the way in which modern Rhythm and Blues music is stylised.

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The authors have no potential competing interests to declare.

Supplementary online material

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