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Effects of mood induction via music on cardiovascular measures of negative emotion during simulated driving

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HIGHLIGHTS

- Cardiovascular correlates of negative mood were captured during simulated driving.
- Low activation music reduced systolic reactivity compared to control condition.
- Negative music influenced cardiovascular responses compared to other groups.
- Mood induction via music moderates cardiovascular correlates of negative mood.

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ABSTRACT

A study was conducted to investigate the potential of mood induction via music to influence cardiovascular correlates of negative emotions experience during driving behaviour. One hundred participants were randomly assigned to one of five groups, four of whom experienced different categories of music: High activation/positive valence (HA/PV), high activation/negative valence (HA/NV), low activation/positive valence (LA/PV) and low activation/negative valence (LA/NV). Following exposure to their respective categories of music, participants were required to complete a simulated driving journey with a fixed time schedule. Negative emotion was induced via exposure to stationary traffic during the simulated route. Cardiovascular reactivity was measured via blood pressure, heart rate and cardiovascular impedance. Subjective self-assessment of anger and mood was also recorded. Results indicated that low activation music, regardless of valence, reduced systolic reactivity during the simulated journey relative to HA/NV music and the control (no music) condition. Self-reported data indicated that participants were not consciously aware of any influence of music on their subjective mood. It is concluded that cardiovascular reactivity to negative mood may be mediated by the emotional properties of music.

1. Introduction

The experience of negative affect has been associated with coronary heart disease (CHD) [27], particularly for those with high trait negative affectivity [1]. Adverse cardiac events linked to CHD have been associated with anxiety [37], depression [5] and anger [35]. The precise impact of each category of negative affect on CHD is complicated by overlap between affective constructs and their related measures [36].

Cardiovascular markers may be used to measure the state of heightened sympathetic activation deemed to be a potential pathway between negative affect and CHD [36]. However, considerable overlap exists between the types of cardiovascular change that are deemed to characterise distinct types of negative affect. The experience of anger, for example, is typified by elevated sympathetic activation coupled with increased respiration whereas a similar pattern (increased sympathetic activation, faster/shallower breathing) is associated with increased levels of anxiety [13]. The cardiovascular response to anger induction was correlated with increased heart rate and systolic blood pressure with a reduction of the pre-ejection period (PEP) [32]. The same pattern of cardiovascular activation has been associated with the experience of anxiety during preparation for public speaking [38] and performance of mental arithmetic [39]. It is likely that commonality between cardiovascular manifestation of negative affect is directly influenced by heightened sympathetic activation of the autonomic nervous system.

Driving represents a common activity in everyday life where the experience and expression of negative affect have implications for health and safety [25,41]. For example, the expression of anger is associated with undesirable behaviour on the road, such as physical and verbal

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abuse, speeding, and tailgating [4,19]. Similarly, increased frequency of violations, errors and lapses has been reported for drivers with high levels of trait anxiety [25]. The trigger for anger or anxiety may originate from unexpected or erratic actions from other road users or be provoked from factors associated with the traffic environment, e.g. stop lights and traffic congestion [17]. For instance, early research using ambulatory monitoring revealed an association between high congestion and elevated systolic blood pressure [24,34] due to a loss of control over journey schedule [10].

The experience of negative emotion and its cardiovascular manifestation may be moderated by environmental factors. Music is one of the most potent techniques for mood regulation and has been found to ameliorate a variety of negative moods [30,42,43]. There is also evidence that people tend to use music to regulate mood states when they are alone [30]. Previous studies have indicated that music is capable of inducing and sustaining positive mood states during the driving task [40]. In this study, participants were exposed to positive and negative music during low- and high-demand traffic conditions and results indicated that positive mood was sustained in the presence of (positive) music despite high traffic density and negotiation of narrow lanes. In addition, the 2000 study by Wiesenthal et al. reported that music (compared to no music) can alleviate stress and reduce aggression during high congestion drives.

Previous investigations into the influence of music on cardiovascular activity have yielded mixed results. Several studies reported that arousing music tended to increase heart rate whilst sad music had the opposite effect [6,11]. However, other researchers claimed that the presence of music per se tended to increase heart rate [12,22]. These contradictory findings may stem from a number of methodological variations across the different studies, e.g. the context of music listening (music in the background or as primary activity), the duration of the musical piece, and the interaction between musical stimuli and personal taste. The categorisation of emotional states may be described as a series of distinct categories (happiness, anger etc.) or within the context of a multidimensional space; for example, the circumplex model [23] proposed two orthogonal dimensions of activation (high vs. low) and valence (positive vs. negative) that encompass a wide range of positive and negative emotional states. A number of studies have studied the impact of different types of music to induce specific moods within the context of the circumplex model. For example, Nyklíček et al. [18] recorded cardiovascular psychophysiology from participants who listened to music deemed to represent each of the four quadrants of the circumplex model of emotion [23], i.e. high activation/positive valence (HA/PV), high activation/negative valence (HA/NV), low activation/positive valence (LA/PV), and low activation/negative valence (LA/NV). They reported that Respiratory Sinus Arrhythmia (RSA) was lowest during happiness and agitation compared to sadness serenity or a white noise condition. Nyklíček and colleagues also reported that left ventricular ejection time (LVET) and PEP increased in the presence of noise and during sad compared to happy music. Krumhansl [14] captured subjective and physiological analysis to various forms of mood music. She reported that heart rate decreased and blood pressure increased during sad music. It is apparent that mood music has an effect on the cardiovascular response but the precise impact is determined by the methodological context.

The current study was designed to investigate the impact of music on the cardiovascular manifestation of negative affect during a simulated driving task. Participants were exposed to an unavoidable delay during a simulated driving journey with a fixed time schedule in order to induce negative affect. This protocol was validated in a previous study conducted by Fairclough and Spiridon [7]. The current study supplemented this protocol by exposing participants to four different categories of music (HA/PV, HA/NV, LA/PV, LA/NV) plus a no-music control group. Our main aim was to investigate how the dimensions of the musical pieces (activation and valence) systematically influenced cardiovascular correlates of negative affect within the context of an unavoidable delay during the simulated journey. We expected HA/NV music to augment cardiovascular reactivity whereas LA/PV music was presumed to have the opposite effect. Our primary goal was to explore whether changes in activation or valence induced by the music were sufficient to enhance or mitigate cardiovascular reactivity to the experience of negative affect in comparison to the control condition.

2. Method

2.1. Participants

The study used a between-subject design with each group including 20 volunteers in total (10 males, 10 females) amounting to 100 participants in total. The mean age of the participants was 21.2 years (SD = 4.7 years, see Table 1). Each person received a £10 voucher ($15/12€) for participation. Two measures of trait anger were taken from the State-Trait Anger Expression Inventory-2 (STAXI-2) [31]: Trait Anger-Reaction (T-Ang/R) and Trait Anger-Temperament (T-Ang/T) to assess any between-group differences in susceptibility to anger. The former refers to the frequency with which anger is experienced during frustration or negative evaluation, whereas the latter represents the disposition of the individual to experience anger in the absence of provocation.

A number of statistical analyses were conducted to test for trait differences between the five independent groups of participants. An ANOVA on age revealed no significant differences between the participant groups. A 5 × 2 MANOVA was conducted on both trait anger scores (T-Ang/R and T-Ang/T) with null findings (Table 1 for descriptive statistics).

2.2. Simulated driving task

A simulated car journey was prepared using a STI SIM Driving Simulator software (STI Inc.). This PC-based software allowed interaction via a steering wheel/pedal console and the driving scene was projected onto a large screen (approx. 3.66 m × 4.57 m) yielding a visual angle of approx. 80°. The simulated journey consisted of a two-lane roadway passing through countryside and urban settings. The route was created so that it could not be finished by the participants. Therefore, after 12 min the drive was stopped.

A clock was visible next to the simulated scene and participants were instructed to complete the journey within 8 min in order to earn the £10 payment for participation in the study. If they failed to complete the journey within this schedule, they were instructed that they would not be paid. This deadline was presented to the participants within the context of a scenario where they were told that the purpose of the journey was to collect a child from school (however, they were not told in advance that it was impossible to make the journey on time). If the driver crashed the vehicle more than twice, they were told that they would lose 70% of their total participant payment. In addition, speeding warnings were in operation (a police siren sounded if the speed limit was exceeded) and participants were informed that they

Table 1
Trait variables for each participant group including means and standard errors (N = 100). Note: HA/PV = high activation/positive valence, LA/PV = low activation/positive valence, HA/NV = High activation/negative valence and LA/NV = low activation/negative valence. Gender represented as a ratio of males:females.

	Age (M, SE)	Gender	T-Ang/R Mean (SE)	T-Ang/T Mean (SE)
HA/PV	20.79 (1.07)	9/11	2.05 (.13)	1.53 (.61)
LA/PV	20.65 (1.04)	10/10	2.08 (.13)	1.53 (.77)
HA/NV	20.95 (1.04)	10/10	2.01 (.13)	1.61 (.72)
LA/NV	20.15 (1.04)	10/10	1.96 (.13)	1.46 (.37)
No music	23.45 (1.04)	10/10	2.42 (.13)	1.61 (.64)