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Effects of noise and music on human and task performance: A systematic review

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Abstract. The purpose of the present paper was to review the literature to develop an understanding of the effects of noise and music on human performance. The second purpose was to study the effects of music on a commonly performed task that is frequently accompanied by background music: driving. Background noise not only affects public health, but it also negatively affects human performance in such tasks as comprehension, attention, and vigilance. However, some studies have indicated that noise exposure may not affect simple vigilance. Despite music's distinct difference from noise it too affects human performance negatively and positively. The results are inconclusive on the effects of music and task performance. More specifically, the effects of music on driving performance are quite similar to that of noise on task performance. Music seems to alleviate driver stress and mild aggression while at times facilitating performance. However, during other conditions of music, driving performance is impaired. Different aspects of sound (i.e. volume, type, tempo) impact human performance differently. It is still unknown which aspect (music or noise) affects task performance to a greater degree.

Keywords: Vigilance, volume, tempo, health, safety

1. Introduction

Background noise is detrimental to tasks involving cognition, concentration and attention [5,13,33]. In contrast, music (sound having harmony, melody or rhythm) has been reported to be as distracting as noise (unwanted auditory signal or disturbance [25] or facilitating) when it comes to human vigilant performance [15,23,50]. Hence, does background music facilitate or detract from driving performance? While driving, many people prefer to listen to a local radio station or their favorite music collection. A driving situation is a perfect example in which a driver is required to have great concentration and situational awareness, while making attentitive decisions. It has been demonstrated that musical stimuli may facilitate one's performance during driving [50]; however, despite these benefits, it may also be a distraction to a driver's attention and performance [6,57]. Studies examining the effects of music and driving performance have reported equivocal results. The purpose of the current review paper was twofold. The first purpose was to examine the literature on the effects of background noise and music in relation to task performance. Secondly, investigate the more specific effects of background sound on driving-related tasks.

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2. Noise

Background noise is a distraction as well as a stressor. According to Leather et al. [45] a decrease in ambient noise in the workplace seems to buffer the negative effects of psychosocial job stress. Historically, noise has been considered a nuisance in society and there are a vast number of publications depicting the negative side effects of this extraneous, unwanted sound [27,43,58,60,64,74]. These detrimental effects not only stem from chronic exposure, but also acute exposure at high volume intensities. Noise not only adversely affects human health [1,43], but it also impacts human performance [13,55]. It is capable of affecting not only one's health and lifestyle, but also task performance.

2.1. Noise adversely affects, sleep and task performance

People who live in highly populated urban areas tend to report sleep disturbances due to noise. Usually, these people live in the vicinity of highways, airports, and other major noise sources [73]. A sleeper's exposure to noise may affect them physiologically and psychologically [73]. Even an individual's performance the following day after exposure to noise during the night is affected [77].

According to Wilkinson [77], when participants were required to perform a simple vigilance test, it was revealed they completed the test faster after a relatively quiet night. Furthermore, simple reaction times during the same task were impaired following a night's exposure to noise. The results reveal that during a night of sleep interrupted or impeded by noise, the quality of sleep is poor and task performance the following day may be hindered. Noise is not only detrimental to one's sleep, but it also impairs vigilant tasks.

2.2. Noise effects on vigilant and cognitive task performance

Noise research involving vigilant and cognitive task performance is not a new phenomenon. Previous studies have demonstrated the adverse effects of acute and continuous noise on vigilance [13,33], attention [36,44], reading deficits and skill [20,51], employee concentration [5], and cognitive processing [8, 48,65].

In the mid 1950s, Broadbent [9] revealed that continuous noise exposure above 90 DBA and longer than 15 minutes attenuates vigilance performance. McCann [53] studied the effects of continuous and intermittent ambient noise. The researcher discovered that there was no difference between the two types of noise in regards to total errors performed on the task; however, intermittent noise produced more omission errors as opposed to continuous noise. Another early study looked at the effects of steady state noise on vigilance [33]. Subjects were exposed to white noise and variable noise at 72 DBA. Subjects decreased their vigilant performance and discrimination during exposure to variable noise, even though the differences were unreliable.

In a study, conducted by Smith [66], 64 female college students demonstrated that noise reduces performance during a task involving the detection of repeated numbers. Additionally, noise also hindered performance during an estimation task. Noise increased the frequency of extremely inaccurate estimates [66].

According to Stansfeld et al. [69], aircraft noise negatively impacts a child's ability to learn. Chronic aircraft noise exposure impaired reading comprehension and recognition memory in children aged 9–10 years. Nevertheless, neither aircraft nor traffic noise affected self-reported health, overall mental health, or sustained attention. Similarly, Hygge et al. [38] revealed that road traffic noise impaired

recollection of text and semantic memory. Noise also impaired attention. However, recognition was not affected by noise.

Furthermore, Hygge et al. [39] studied two school aged children populations. One group consisted of children attending school in an area of a new airport development (aircraft noise) and the other consisted of children attending school in the vicinity of a recently closed airport (quiet). The researchers discovered that after the opening of the new airport, the children's long-term memory and reading comprehension were impaired. Nevertheless, the quiet group demonstrated improvements in reading comprehension and short and long-term memory. Thus, it is quite possible external traffic noise may play a role in impairing cognition in school aged children.

Recently, Button et al. [13] studied the effects of industrial noise and muscle contraction on vigilance. Loud industrial noise exposure significantly increased the duration of reaction and movement times during simple vigilant tasks. Respectively, loud industrial noise decreased a complex vigilance task to a greater degree. It was noted that loud sound exposures had a greater effect on tasks involving higher levels of concentration because higher amplitudes of auditory stimuli require greater central resources for processing sensory information. Another speculation involves the increase in anxiety levels during exposed to loud intensity sound. This increased anxiety may potentially over arouse the central nervous system, thereby decreasing one's responsiveness to vigilant specific tasks.

Conversely, past studies have demonstrated that noise does not impair or may even improve simple vigilance tasks. During a simple addition task, Harrison and Kelly [32] discovered that ambient white noise (80 DBA) improved performance compared to a quiet (52 DBA) condition. Further, Harcum and Monti [31] demonstrated no effects of loud ambient noise (100 DBA) on visual and card sorting tasks. Despite evidence of the negative effects of noise, equivocal results still exist especially in relation to music.

3. Music

Music is a popular source of leisure in today's society. It has been demonstrated that music affects individuals psychologically [41], physiologically [7,37,70] as well as socially [2,3]. However, the reasoning underlying why an individual responds accordingly during exposure to music is debatable [46].

3.1. Music facilitates task performance

Previous studies have shown that moderate volumes of background music facilitate performance in activities that involve high levels of concentration and attention [15,18,21,23]. For example, Corhan and Gounard [15] demonstrated that rock music improved performance on a signal detection task compared to relaxing instrumental music. Davies et al. [18] found that during a difficult visual vigilance task, music exposure prevented detection latencies that were evident during no music. Furthermore, Ferguson et al. [21] studied the effects of listening to music prior to a karate task performance. Regardless of the type of music (fast-tempo, loud versus slow-tempo, soft) mean ratings of trials performed were significantly higher compared to performances after white noise. Music facilitates such performance because the stimulus is considered stimulating, in that it increases motivation, arousal and perception of energy [4, 18,50].

3.2. Music is distracting

It has been shown that music is capable of distracting or deterring performance of certain tasks [16,19, 22,40]. Etaugh and Michals [19] conducted reading comprehension tests on 32 college-aged students. Participants were exposed to two conditions: familiar music or quiet surrounding. Females performed more poorly when exposed to the music compared to the quiet scenario. However, male participants performed equally during both conditions. Nevertheless, it may not be the preference of the sound type that is the problematic distraction during music exposure. Despite the differences, noise being defined as an unwanted sound or sound that is unpleasant and may be annoying to the listener [26] and music as consisting of sound displaying harmony and rhythm, Furnham and Strbac [25] found that music is as distracting as noise. The researchers discovered that performance during a reading comprehension task was significantly worse with music in comparison to silence. There was also a significant difference between silence and noise, in which the noise condition showed worse performance. However, there were no significant differences in performance between the noise and music conditions. Thus, music and noise may be considered just as distracting during a comprehension task.

Alternatively, the tempo of music has been shown to affect human task performance [40,52,54,56,67]. Fast tempo music increases the performance speed of an activity [10,54]. For example, McElrea and Standing [54] studied the effects of fast and slow music tempo on subjects' duration to drink a can of soda. They discovered that the faster pace music decreased drinking time significantly compared to slower music. Further, Kallinen [40] demonstrated studied the effects of background noise and music tempo on reading efficiency and time. It was demonstrated that slow tempo music impaired reading efficiency, while increasing reading time compared to cafeteria noise. There were no differences between a noisy cafeteria and fast tempo music. However, fast tempo music improved reading performance compared to slow tempo music. Music definitely has an effect on task performance.

4. Driving related tasks and background music

The main method of transportation in today's society is driving an automobile and the common tendency is to turn on the car radio or stereo system upon entering the vehicle [12]. Listening to music while driving is an increasingly popular practice. Ninety percent (90%) of transportation transits include musical exposure [63]. Music has the capability to influence driver stress [75], subjective anxiety [47], relaxation [70] and even the speed at which one drives [10]. Further, it has been suggested that listening to heavy metal or hard rock music is correlated with negative behaviors, such as reckless driving and traffic accidents amongst younger drivers [2,28]. Music has the ability to affect driving performance both negatively and positively. Exposure to music has also been shown to facilitate one's performance [72]. It is unclear whether music is beneficial to driving and controlling an automobile. Thus, it is of an increasing concern to study the effects of music on driving and related tasks.

4.1. Early driving and music studies

Driving research in respect to background radio sound is not a new phenomenon. Early research began in the 1960s [11,42]. One of the early pioneer studies conducted by Brown [11] studied the effects of background music, speech and silence during light and heavy traffic. Eight subjects were tested on a 2.2-mile standard test circuit. Subjects were tested on the use of car controls and duration to complete the designated course. It was reported that music significantly reduced the frequency in which

the accelerator and brake pedals were used in light traffic. Meanwhile, during heavy traffic, the music condition increased the amount of time taken to complete the circuit. Brown [11] reported the findings as music reducing stress on the driver and lowering emotional arousal under frustrating circumstances of driving in heavy traffic. The music provided an alternative stimulus in which attention is averted. However, it was noted that listening to music had insignificant adverse effects on driving performance pertaining to the experiment. It was even speculated that listening to music might have a slight beneficial affect during driving in that it reduces frustration caused by certain stressors (i.e. heavy traffic).

Konz and McDougal [42] involved 24 automobile drivers. The participants were required to drive on a four-lane divided highway for 11.5 miles. The circuit was not closed. The participants were exposed to three separate conditions: silence, slow music and Tijuana brass music. Drivers participated in greater control activities (i.e. steering wheel movements, brake usage, and accelerator usage) during more 'peppy' music or the Tijuana brass music. However, it was reported that it was difficult to distinguish whether these control activity changes were positive or negative [42]. Furthermore, both types of music were shown to increase control activity. An arousal effect was a factor in the speed increases. During the background music, the driver was more aware and alert, which led to faster lap times. The researcher concluded that greater alertness, would lead to greater improvement in driving [42]. The previous studies are the basis of driving research in relation to background music.

4.2. Background music affects driver stress and anxiety

Automobile driving, at times, is extremely irritating and stressful [29,34,49,75]. It may even evoke aggressive behavior [35,76]. However, a preventative measure to reduce stressful situations during driving an automobile is to listen to one's favorite music collection. Musical therapy has been shown to reduce stress [30,71] and blood pressure [14] as well as enhance relaxation [70], thus alleviating driver stress. According to Wiesenthal et al. [75] music is an important mechanism in coping with driver stress. Yet, the impact of music is unnoticed during low traffic congestion scenarios. The researchers studied commuters in two types of scenarios: when listening to one's favorite music and when traveling in silence. During both conditions driver stress significantly increased during high congestion traffic compared to low. Nevertheless, during the silence situation, driver stress increased significantly more in high congestion traffic as opposed to the music condition. During high congestion, music exposure seemed to have a soothing effect on driver stress [75]. The authors speculate that music is alleviating during undesirable circumstances by distracting drivers from frustrating events, such as heavy traffic.

In a follow up study, high congestion traffic had an increasing effect on mild driver aggression [76]. Therefore, music was studied to determine if it had a comparable response on driver aggression as it did on driver stress. Similar results were reported. During high congestion traffic, listening to one's favorite music lowered mild aggression. It has been considered that music is capable of obscuring peripheral environmental stimuli during cognitive and motor tasks [24,59]. During music exposure, drivers are less aware of potential environmental stressors or frustrating occurrences that would normally increase aggression while driving. Hence, musical listening is distracting towards irritating and frustrating driving-related events [76]. Furthermore, familiar music also has a relaxation effect on an individual. However, due to the distracting nature of music during motor vehicle control, the driver's performance is at risk in an effort to decrease aggression and stress.

4.3. Background music tempo and driving performance

Music tempo has an affect on driving performance. Higher tempos are symbolic of today's popular hard rock music. Yet, there is little research on tempo of music and driving tasks. A recent study

discovered that faster music in respect to beats per minute increases both simulated driving speed and one's perceived driving speed [10]. Brodsky [10] found that subjects not only drove faster with a faster music tempo, but they also perceived themselves to be driving faster. Additionally, participants underestimated their faster recorded driving speeds by approximately 45 kilometers per hour less during the faster tempo condition. Therefore, drivers partake in more at risk behaviors when listening to higher tempo music. Drivers also had greater incidences of collisions, lateral weaving, and disregarded red lights, which indicates that tempo of the music causes rhythmic contagion or even entrainment [10]. It is safe to state that music tempo plays a role in the stimulation [10]. Faster-paced background music affects drivers' performance, but there have been conflicting results on whether or not music facilitates or distracts a driver's ability to perform vehicular controlling tasks.

4.4. Background music and driving performance: Equivocal results

Music has been shown to facilitate performance during driving related activities [6,50,61,68,72]. Comfortable or moderate intensities of background musical stimuli improve one's performance when partaking in driving-related tasks. As reported by Spinney [68], quiet music played at 55 DBA provides for optimal driving conditions when compared to silence and loud music of 85 DBA. Listening to the quieter music condition will improve reaction time and awareness to avoid hazards [68]. Improved performance and alertness is related to music exposure matching one's comfort level [72]. Turner et al. [72] demonstrated that reaction and total response times to unexpected external stimuli are a U-shaped function of music amplitude. Moderate music (70 DBA) improved response time to a randomly activated red light in comparison to quiet music (60 DBA) and loud music (80 DBA). However, movement time was not affected. Moderate intensities of background music stimulate driver awareness [50].

The arousing nature of hard rock music may lead to the postulation that loud rock music has the ability to enhance reaction times or speed one's awareness or detection of unexpected hazards during certain scenarios [50]. Matthews et al. [50] discovered that response times to cued stimuli were significantly improved when the subjects were exposed to rock music. The researchers concluded that loud rock music has a tendency to enhance energy and maintain interest in a specific task during stressful and non-stressful situations. The results somewhat differed from Wiesenthal et al. [75], who claimed that music only enhances concentration towards driving during high congested traffic. Nevertheless, Matthews et al. [50] did show that moderate intensity rock music facilitates driving performance in both irritating and nonirritating conditions, but not during loud rock music (intensity only ranged between 70–90 DBA).

Further, Beh and Hirst [6] found that during high-demanding situations loud music (85 DBA) facilitates performance of vigilance when signals are centrally located. Under certain circumstances, louder volume music is even superior to lower volumes (55 DBA) for facilitating attentional focus to vigilant performance. High intensity music may prove beneficial to performance under high arousal situations.

The literature is inconsistent in reporting the results of music and its effects on driving related-tasks. Even though music has been shown to facilitate driving performance and behavior, it is still considered a major distraction and detrimental to one's cautious driving abilities according to some studies [6,57, 62,68]. Beh and Hirst [6] concluded that music did not facilitate performance during simple tracking tasks, which required continuous motor involvement and visuomotor coordination. And loud music did not interfere with tracking performance. Yet, loud music significantly affected response time to peripheral stimuli, which counter-balances the facilitation effect of the researchers findings related to centrally located stimuli. Moderate intensity music facilitated performance requiring a wide attentional span, whereas loud background music impaired performance under similar conditions [6,57].

Furthermore, high arousal music competes for limiting processing space within the cortex [57]. Greater cognitive space is required during high arousal stimulation, to process the external information. North and Hargreaves [57] demonstrated that high arousing music, increased lap times and impaired performance during simulated driving. Hence, higher arousing levels of music will in turn impair cognitive or driving related performance [57].

More recently, Dalton et al. [17] studied the effects of sound type and volume on driving related tasks. The authors found that irrespective of sound type (noise, hard rock, or classical music), loud intensities (95 DBA) impaired simulated driving and simple vigilance performance as compared to quiet intensities (53 DBA). Thus, different types, intensities and tempos of sounds may have different effects on driving performance.

5. Conclusions

We are exposed to music and noise in various situations: at work, while driving, during leisure activities. Thus, it is important to understand the effects that these stimuli have on human and task performance.

1. Noise disturbs a well-rested nights sleep and impairs human performance on vigilance tasks the following day.
2. Acute and continuous noise adversely affects vigilance and comprehension.
3. Music results are equivocal. Music may facilitate performance involving high levels of concentration and attention. Conversely, music has also been shown to be as distracting as noise during comprehension tasks.
4. Fast music tempo increases the speed at which one completes a specific task. However, a fast music tempo also increases the number of mistakes during that task.
5. Music is distracting towards peripheral stimuli during frustrating situations (i.e. heavy traffic congestion). Thus, music can reduce stress and mild aggression. However, the distracting nature may impede simple vigilance performance during these situations (i.e. maneuvering to avoid another vehicle or pedestrian).
6. A moderate level of music is optimal for activities requiring careful attention and concentration (i.e. driving) because it closely resembles one's comfort level. However, the determination of a moderate level is subjective to the listener.
7. Finally, irrespective of sound type, loud volume intensities impair human performance during simple vigilance and simulated driving tasks.

The effects of noise and music on varying tasks, including driving, play both a facilitating and distracting role. Further research in this area is needed to distinguish the optimal background stimulus to enhance human and task performance.

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