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Background Music As A Risk Factor For Distraction Among Young Drivers: An IVDR Study

Warren Brodsky,*[1] Zack Slor#[2]

*Music Science Lab, Department of the Arts, Ben-Gurion University of the Negev, Beer-Sheva Israel
#Israel Center For Emotional Fitness, Zahala Tel Aviv Israel
[1]wbrodsky@bgu.ac.il, [2]zackslor@gmail.com

ABSTRACT

Statistical data on road safety indicates that drivers between ages 16-24 account for a high level of accidents and fatalities; in Israel 25% severe accidents and 5% fatalities occur during the first two years of driving, and young novice drivers are 10-times more likely to be in an accident during their first 500 miles. Ironically, the most common violations for this group are speeding (37%) and lane weaving (20%) – both of which correlate with in-cabin music behavior (Brodsky, 2002). Young drivers regularly listen to fast-tempo highly energetic aggressive music played at elevated volumes. This State of Israel National Road Safety Authority study investigates music as a risk factor among young novice drivers. The study employed two Learners Vehicles installed with in-vehicle data recorders (IVDR). Eighty-five young novice drivers drove six trips: twice with preferred music brought from home, twice with In-car alternative music (Brodsky & Kizner, 2012), and twice with no-music. For each trip 27 events were logged; a range of vehicle variables that were mechanical, behavioral, or predetermined HMI interactions. The findings indicate that both frequency and severity of driving violations were higher for trips with driver-preferred music than trips when either no music or In-car alternative music. We recognize that in-car listening will forever be part of vehicular performance, and therefore future research should explore the effects of music on driving performance. Developing and testing functional music backgrounds towards increased driver safety is an important contribution of Music Science in the war against traffic accidents and fatalities.

I. INTRODUCTION

A. Vehicular Music Listening

The investigation of music in everyday life documents how real people employ music in particular spaces and settings. Apparently, not only do we do things to music, but most of the time we do things with music; we ride, eat, fall asleep, dance, romance, daydream, exercise, celebrate, protest, purchase, worship, meditate, and procreate – with music playing in the background (DeNora, 2000). Sloboda's (1999) landmark investigation demonstrated that activities accompanied by music are predominantly domestic or solitary, and most frequently include transportation or housework. In a follow-up study (Sloboda, O'Neill, & Ivaldi, 2000, 2001) diary-type journals were written subsequent to hearing a random pager signal 7-times per day for one week; music experienced was twice as frequent for episodes involving transportation (91%) than home (46%) or workplace (5%).

It is somewhat absurd that the popular location where individuals seem to be found when they listen to music is not in the comfort of their living room, nor is it shared with social agents such as intimate partners, extended family, or friends. Rather, the circumstance most frequently reported while listening to music involves unaccompanied vehicular driving. It should not, then, be surprising that automobile consumers outfit their vehicle as an audio-environment. For some time drivers have further customized their cars with audio-components including changers, amplifiers, equalizers, and speakers of various configurations and frequency ranges. Moreover, the once-upon-a-time standard AM/FM car-radio receiver, long ago replaced by the cassette tape player and compact-disk CD player, has today become a vehicular entertainment center; a central media-driver for a host of auxiliary input devices such as USB flash memory sticks, portable disk drives, MP3 players, iPods, iPhones – as well as dash-mounted palms, DVD-players, and mobile internet work-stations. It should be pointed out that these devices have already been found to have the same or worse effects as cell phone use (Brumby, Salvucci, Manowski, & Howes, 2007; Salvucci, Markley, Zuber, & Brumby, 2007).

The relationship between music, driver, and the automobile was studied by Oblad (2000) who presumed that more than just attraction, individuals have specific expectations when they play music in the car. She felt that it is not necessarily the music drivers want to listen to, but rather, they simply want to spend time in the car with accompanying music. She postulated the existence of an interactive co-dependent relationship between driving and music, which was conceived early in one's driving history during the mid-late teen-years. Oblad's participants reported being aware of choosing music pieces differentially; they described the effects of music as influencing both their rhythms of driving and concentration, as well as charging their perceptions of relaxation and stimulation. Oblad noted that when a driver liked the music the sound level could never be high enough, always causing accelerated cruising speeds. The drivers reported to feel 'near' or 'inside' the music, and perceived the experience as 'impenetrable'.

B. Effects of Music on Vehicular Control

Intensity. In-cabin driver-adjusted acoustic outputs were measured by Ramsey and Simmons (1993) in ranges between 83-130dBA. Obviously, one must question if music presented at these intensity levels impede on driving performance placing the driver at increased risk, or facilitate driving performance reducing actual everyday hazards. For example, Ayres and Hughes (1986) found that while visual search and pursuit tracking tasks remained unaffected, visual acuity was impaired by loud music (107dBA). This seems to suggest that momentary peak levels in loud music play a role in disrupting vestibulo-ocular control. Such findings perpetuate general beliefs that soft music facilitates driving while loud music impairs vehicular control. Although there have been some studies (e.g. Spinney, 1997; Turner, Fernandez, & Nelson, 1996) who challenged such speculations by demonstrating that music exposure during driving actually increased performance ability with improved reaction times, others found interaction effects between music intensity and focus of attention. For example, Beh and Hirst (1999) explored low-demand single-task driving versus high-demand multi-task driving under soft (55dBA) and loud (85dBA) background music conditions. These findings indicate that while simple tracking tasks were not affected by music at either intensity, and that response times to centrally located visual signals improved with both intensities (i.e., shorter stopping times to critical signals in the driving environment), louder music significantly increased reaction times to peripheral signals during high-demand driving. In summary, while it could be argued that moderately-loud music may be beneficial to driving under increased attentional demand for signals located within central vision, the trade-off of an increase in response time to peripheral signals essentially nullifies any advantage.

Tempo. For some time researchers have been aware that background music variegated by tempo affects drivers; Konz and McDougal (1968) reported accelerated driving speeds with rapid music, and Iwamiya (1997; Iwamiya & Sugimoto, 1996) reported differentiated perception of windshield-view scenic landscapes based on musical pace. In contexts where the visual field is a constantly changing stream (such as during vehicular driving), the perception of *time* seems to overlap with perception of *velocity*. Apparently, when confounded with background music, such inconsistencies relate to the fact that music itself is a temporal stimulus, and that sensory input of a temporal nature interferes with other temporal perceptual impressions (such as internal timing mechanisms). Clearly, temporal perception relates to the number of events processed within a given period, and therefore impressions can be baffled by both the amount of memory taken up by an event, as well as with the number of changes that occur during a specific period (Zakay, 1989). Hence, music which moves at higher levels of perceived activity or faster tempos will cause differential perceptual effects versus music which moves at lower levels or slower tempos. Brodsky (2002) investigated the effects of music tempo on simulated driving acceleration and virtual traffic violations under conditions with no background music, slow-paced background music (40-70bpm), medium-paced background music (85-110bpm), and fast-paced background music (120-140bpm) – while controlling for intensity (at a standard 85dBA). The results indicated that as the tempo of background music increased, so too did both simulated driving speed and the frequency of virtual traffic violations (including: vehicular accidents and collisions, lane crossings or increased vehicular shifting of lateral position referred to as 'weaving,' and disregarded red traffic-lights). Finally, confirming outcomes by Gregersn and Berg (1994), the study found that faster drivers demonstrated significantly more at-risk simulated driving behaviors with fast-paced background music than did slower drivers. Brodsky concluded that music tempo was accountable for distraction effects, and suggested differentiating between 'music intensity evoked arousal' and 'music tempo generated distraction'.

C. Relevance of Music to Traffic Violations and Accidents

The number of music-related automobile accidents and highway fatalities is not a known statistic. The car radio, first introduced to American motorists by scientist Paul Gavin in 1929, blares from the windows of automobiles passing by; the last thing drivers (and policemen) think about is how unsafe it might be to turn listen to music during driving. Yet, many studies have looked at changing a radio channel, cassette tape, or CD as a form of mental distraction attributed to fatalities (for example, see: Stevens & Minton 2001). More specifically, the 2000 Quicken Insurance Survey was the first to find a more specific and alarming picture: almost all drivers insured by Quicken (91%) reported daily driving with music playing in the background, and almost all (95%) of those with one or more traffic violations during the prior 1999 year had been driving at the time with music - 33% reporting to have been listening to fast-paced loud music.

Statistical data on road safety indicate that, at least for Israel, drivers between ages 16-24 account for the highest level of accidents and fatalities (Shinar, 2004). It seems, then, that two essential predictors of traffic-related accidents and fatalities are 'age' and 'license date' – with roughly 25% severe accidents and 5% fatalities occurring during the first two years of driving. Based on a 10-year analysis of the US National Highway Traffic Safety Administration's Fatality Analysis Reporting System data on fatal motor vehicle crashes between 1998 and 2007, the AAA (2009) reported that 24,655 young drivers were involved in 24,198 fatal crashes that killed 28,138 people. Of the 28,138 people who died in crashes involving young drivers, 10,388 (36.9%) were the young drivers themselves, whereby another 8,829 (31.4%) were passengers of young drivers, and 6,858 (24.4%) were occupants of other vehicles operated by drivers at least 18 years old.

Ironically, Shinar (2004) reported that the most common traffic violations of this group were speeding (37%) and lane weaving (20%), both of which have been reported to correlate with in-cabin music behavior (Brodsky, 2002). Such a situation is especially distressing when considering that current lifestyles place youngsters aged 16-24 years old behind the steering wheel more often than in the past. Young drivers regularly choose to travel with music playing in the vehicle, and plan in advance which tracks to take along for the ride. Unfortunately, the music they seem to be listening to while driving is not only highly energetic aggressive fast-paced music, but is reproduced at high volume levels. Hence, alternative music backgrounds could, in principle, modify driving behavior and therefore assist in the war against traffic accidents. With this goal in mind, Brodsky & Kizner (2012) developed a functional music background referred to as *In-Car Music: An Alternative Music Background Designed For Driver Safety*.

II. METHODS

While music investigations with PC simulated driving in virtual vehicles on animated roads provide a wealth of data from tightly controlled manipulated conditions, these do not necessarily consider real driving tasks in a dynamic environment, a three-dimensional visual field, time-sharing strategies, and distinct behaviors related to survival (as far as the perception of risk is concerned). Most specifically, it is not known if visual stimuli presented on a computer screen might be more easily overwhelmed by dynamic music stimuli than on-the-road driving – which also involves real-world perceptual cues from engine noise and revs, vibrations, motor feedback, weather conditions, pedestrian density, additional traffic, and passengers. The current study was designed as a 3-condition within-subjects repeated-measures on-the-road field study in an automobile installed with an in-vehicle data recorder monitoring system accompanied by a certified driving instructor. Every young novice driver drove 6 trips: 2 trips with driver-preferred music, 2 trips with experimenter-supplied In-car alternative music, and 2 trips with no-music (as a control and baseline condition).

A. Participants

Eighty-five (N=85) young novice drivers participated in the study; there were 50 males (58%) and 35 females (42%), between 17-18.6 years old ($M = 17.6$, $SD = 0.41$), with a valid Driver's License for an average 7 months ($SD = 2.64$). The sample was recruited from an area covering 650 square-kilometers (403 square-miles); they were from low-to-upper middle-class families. The majority (86%) reported to listen to music all the time while driving in a car, almost all (99%) listen to a music background they described as moderately-fast/very-fast paced, to which most (94%) play at moderately-loud/loud volumes. Each participant received a gift voucher ($50) as an honorarium.

B. Driving Instructors

A local transport authority referred two senior driving instructors. They were both male, on average 62 years old ($SD = 2.83$), with a similar 39-years experience as a licensed driving teacher. Each instructor brought his own fully insured automatic-gear Learners Vehicle to the study: a Red 2011 Volkswagen Polo 1200TSI-DSG7 and a White 2008 Suzuki SX4 Sedan 1600cc. An in-vehicle data recorder was installed in each car.

C. Equipment

An in-vehicle data recorder (IVDR) (*VU*, Traffilog) forms and maintains a direct connection to the controller area network (CANBUS) and on-board diagnostics (OBD) of the car. *VU* technology allows it to 'read' all protocols of every car brand and model, as well as to accurately measure the applied G-force during driving (enabled by the 3D G-sensor and ECM systems). The *VU* IVDR is comprised of single end-unit installed under the dashboard, a numerical keypad, and a web-based software application. See Figure 1. Traffilog's innovative unit and decoder-connection collects raw data from driver behavior and vehicular performance at a sampling rate of 100ms, which are transmitted and synchronized to a secure database in real time with continuous on-air updates every 10s. Although based on GPS/GPRS and GSM technology, in the event of a coverage disruption or disconnection, the *VU* IVDR records and logs data locally; once the connection is restored all data is transmitted. With the use of sensors that measure acceleration between two axis as well as GPS and diagnostic data, applications can calculate G-sensor triggered events and label them by score as aggressive driving.

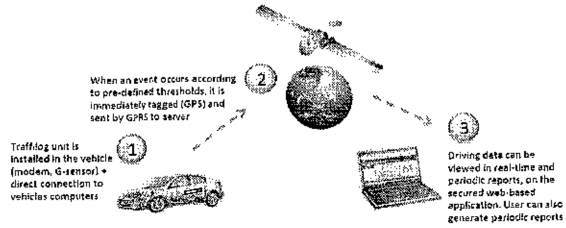

Figure 1. Traffilog's innovative Vehicular Unit (VU)

D. Measures

The current paper focuses exclusively on the driver diagnostics package used co-jointly with the IVDR. Traffilog's in-vehicle proprietary software processes a range of vehicle variables that are both mechanical and behavioral, as well as sets of predetermined human-machine interface (HMI) interactions between variables. The protocol used logged 27 event-behaviors from six event-categories, including: speeding (3-levels), breaking (7-levels), left/right turns (4x2 levels, turning w/acceleration, turning w/breaking), and increased rpms in acceleration (5-levels). The analysis provides data interpretation capabilities based on thresholds of event frequency and severity scores. Three levels of driver behavior classified are Cautious, Moderate, and Aggressive.

E. Music Stimuli

The study compared between two driving conditions variegated by in-cabin listening backgrounds; driver-preferred music brought from the participants home versus In-car alternative music supplied by the experimenter. Roughly half (48%) of the CDs brought by the drivers were Israeli music of various styles, including: Pop, Rock, Hip-Hop, Reggae, Ethnic, and Jewish-Soul; other genres were American/British Pop-Rock (34%), Reggae and World music (9%), Classical music (5%), and movie soundtracks (4%). In a debriefing procedure, the majority of participants (96%) rated the music they brought from home as either moderately similar (51%) or highly similar (45%) to the music they usually drive with everyday. The experimenter-supplied music was developed by Brodsky and Kizner (2012). Using an aural structural design for music that can furnish an optimal acoustic background for improved vehicular driving (Brodsky, 2002), these pieces have been found to maintain alertness and positive moods without diverting cognitive resources. The 30-minute music program consists of eight pieces which are a blend of easy-listening, soft-rock, and light snappy up-beat smooth-jazz, with a touch of ethnic world-music flavor; the tracks do not include vocal performances involving lyrics, nor instrumental cover-versions of well known popular tunes. The typical orchestration is a rhythm section with melodic fragments intermittently surfacing, but without a specified melody line to sing along with. This functional music background is referred to as *In-Car Music: An Alternative Music Background Designed For Driver Safety*.

F. Procedures

Recruiters accumulated names of prospective participants. Details about the study were offered by phone and then in writing; a parent signed an informed consent to participate for each participant. Trips were scheduled by the accompanying driving instructors. The participants came to their initial session with their preferred music CDs; these remained in the Learners Vehicle throughout the study. Each participant was randomly allocated a pre-numbered booklet for collecting behavioral data; each was pre-assigned a unique rotated series dictating implementation of the empirical conditions for each of six driving trips. All driving trips were semi-structured. In the first 10-minute segment the participants drove out of their personal neighborhood via limited-access residential roads towards the closest divided boulevard leading to a hi-way. Then, for roughly thirty minutes, the participants drove along urban interstate freeways constructed of 2-lanes or more in each direction. Finally, in the last 10-minute segment the participants drove home. All subsequent trips were exactly identical in structure, with the exception of debriefing and payment in the final trip.

While the field-study was spread over a 10-month season, every driver-participant completed all six trips within a two-week time frame, in the same Learners Vehicle with the same accompanying driving instructor. In total, there were 510 trips of roughly 42 minutes (*SD* = 3.38), over a distance averaging 39.4 kilometers (*SD* = 6.99, ca 25 miles). No general effects surfaced for trip-*time*, trip-*distance*, and trip-*speed* between the driving conditions; nor were there meaningful interactions of these parameters between the two driving instructors.

III. RESULTS

Mechanical data from an in-vehicle data recorder supplied scores from six trips. Twenty-seven event-behaviors from six event-categories were tabulated, collapsed across trips variegated by driving conditions, and calculated. Two accumulative scores were brought forward: frequency of events per condition, and the severity of event per condition. See Table 1. When entering these into two separate repeated-measures *ANOVA*s, statistically significant effects surfaced (Frequency: $F_{(2, 168)} = 5.1108$, $MSe = 18.498$, $p < 0.01$; Severity: $F_{(2, 168)} = 5.2009$, $MSe = 5252.80$, $p < 0.01$). Comparison between the conditions indicates that at-risk driving was statistically significantly greater for trips with driver-preferred music than either trips without music background or with In-car alternative music background; no significant differences surfaced between the later two conditions.

Driving Events	I NoMus M	SD	II DrvPrefMus M	SD	III In-carAltMus M	SD
Frequency Of Violations	10.12	(6.88)	11.93	(7.53)	10.09	(6.87)
Severity Of Violations	158	(120)	189	(132)	157	(111)

Table 1. In-Vehicle Data Recorder: Driving Violations

In an attempt to highlight the benefit or detriment of music during driving, no-music data (emulating a baseline condition) was deducted from data of music conditions. These new variables were then entered in separate repeated measures *ANOVA*s; there were statistical effects across conditions. Frequency of violations ($F_{(1, 84)} = 7.1534$, $MSe = 20.141$, $p < 0.01$); and Severity of violations: ($F_{(1, 84)} = 7.4964$, $MSe = 5669.6$, $p < 0.01$). See Figure 2. As can be seen, the driver-preferred music significantly increased both frequency (left panel) and severity (right panel) of violations above no music 'neutral' baseline, while the opposite occurred for In-car alternative background.

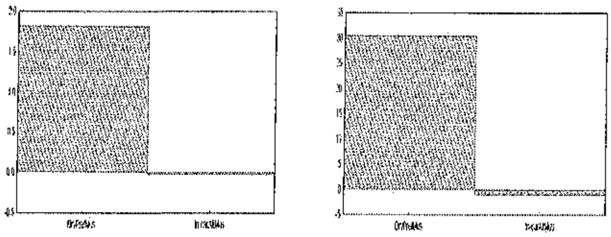

Figure 2. Effect of music on driving violations: frequency (left panel) and severity (right panel). 0 = no-music baseline.

Then, employing severity scores as an index, driver-participants were graded into three overriding classes (referred to as *New Driver DNA*) metaphorically presented as colors Green, Yellow, and Red. *NDNA* is interpreted as driver behavior subtype: Cautious, Moderate, and Aggressive. See Figure 3. As can be seen in the left panel roughly 64% of the participants were classified as Moderate drivers. However, a more focused analysis on the proportion of *cautious* versus *aggressive* drivers in each driving condition was implemented. As can be seen in the right panel, the proportion between the two driver subtypes is roughly the same for trips with No-music as well as for trips with In-car alternative music background. But when driving with preferred music in the background, the proportion of *aggressive* drivers (n = 22, 69%) was much greater than *cautious* drivers (n = 10, 31%); this difference between driving behavior subtypes was statistically significantly ($p = 0.0266$).

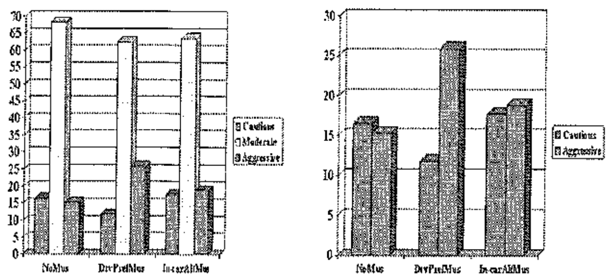

Figure 3. New Driver DNA (NDNA)

IV. DISCUSSION

While music may not be the risk factor for perceptual distraction leading to impaired vehicular control, it is certainly possible that music is more of a contributing risk factor than currently perceived. To date there have been no documented objective measures of music's ill-effects during driving; the literature solely cites survey studies, and a few PC-controlled simulations. Hence, a real-world on-the-road field-study that targets in-cabin music experiences is needed as a means of illuminating driving profiles variegated by the frequency and severity of violation. In addition, IVDR monitoring seems to be a logical step in extending the research-driven knowledge base, in particularly related to in-cabin music stimuli and young drivers music behavior. The current study indicates a differential of music effects on vehicular control as based on music background. More studies are welcome in an effort to explore all possible mechanical and human variables related to driving and accident prevention.

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