Analyzing High Decibel Honking Effect on Driving Behavior Using VR and Bio-Sensors

by

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Abstract
Honking in traffic is an auditory warning to indicate: driver's actions, alert pedestrians and to convey an emergency situation requiring right of way. Though studies have shown the importance of honking in maintaining traffic flow, there have been cases where irrational use leads to an increase in stress/irritation with effects on driver decision making. Most drivers are unaware of the adverse health effects of high decibel honking. In this report, we looked at the effects of honking on driving behavior in a lab-developed VR driving simulator and anxiety/stress as indicated by changes in skin conductance /pulse rate measured using sensors.

Author Keywords
Galvanic skin response; honking; virtual reality; anxiety.

CCS Concepts
•**Human-centered computing** → **Virtual reality;**

Introduction
Irrational honking is a persistent problem, especially in countries with heterogeneous road traffic. When the development of road infrastructure is not on par with the increasing vehicle density, the problem is compounded as driver's cognitive load increases leading to irrational use of honking to influence traffic flow. There have been studies which considered the honk effect on traffic flow and pedestrian

movement. Jia et al. [2] shows that honking has no effect in homogeneous traffic. However, there was a considerable enhancement in the traffic flux of intermediate density for heterogeneous traffic. In a similar work, Wen et al. [6] presented numerical simulation and results verified that the driver's characteristics and honk effect have a considerable impact on the stability of traffic flow. These findings highlight that honking plays a critical role in the stability of the traffic flow. However, only a reasonable amount of honking has a positive impact on traffic flow.

The goal of this work is to study the dynamic driver behavioral (independent factor) in different honking environments (dependent factor) similar to real-life situations. To achieve this, a simulation of typical Indian traffic was developed and presented using VR. High decibel honks usually fitted to a bus, truck and a car were used as the auditory input. The simulation presented a set of possible decisions a driver can choose from. The option chosen was rated to indicate the level of irritation due to honking.

Figure 1: First person view in the Simulator through VR

Methodology

Skin Conductance for Anxiety

Previous works [1, 3, 4] have shown that honking has a considerable effect on the person's autonomic nervous system resulting in anxiety and which in turn has been shown to result in incorrect decisions [5]. Anxiety manifests in measurable physiological changes like skin conductance (GSR) and pulse rate, hence used as a valid measure [1].

Participants

The experiments were conducted on 45 participants. The average age was 28 years (ages: 18 to 51 years; stdev = 9.49). Experienced drivers (total: 17) with an average of 4.8 years of driving experience and the rest had little or no experience. 29 were male and 16 were female participants. Consent was taken from all participants, and were informed that they could stop the experiment at any time. For this experiment, the main focus was on young/inexperienced drivers as old/experienced population shows adaptation or the ability to filter out noisy environment.

Simulation

A game was designed in Unity 3D game engine as a first-person (Figure 1) driving simulator wherein the participant can control a virtual car on a road with a typical heterogeneous traffic scenario. The participant wears a VR headset and uses the steering-wheel as a controller. The traffic simulation includes vehicle bots designed on a rule-based engine. Three honk/vehicle type conditions were preceded by a standard decibel test to ensure the normal functioning of the participant's hearing system. For all the scenarios, the participant's task was to drive to reach a traffic signal and then wait for the signal to turn 'green'. A vehicle (car, bus or truck) will trail the participant's car and honk persistently. The lane on the left of the driver's car is shown to be vehicle free for the participant to shift and give way for the trailing vehicle. Each participant behavior change under honking stress was analyzed on the following decisions:- (i) Break the traffic signal rule - irrational decision (ii) Note/observe the opening in the adjacent lane - observation affected due to anxiety (iii) Move to the adjacent lane to give way for the trailing honking vehicle - rational but stress affected decision. Post the VR experiment, a self-report survey is provided to rate on the noise induced irritation and immersive experience of VR simulator.

Setup

To study driver behavior, a simulator designed for near-real ambience and immersion of a car driving experience was developed. The VR headset provided 110-degree FoV of traffic scene for realistic situational awareness. A game-

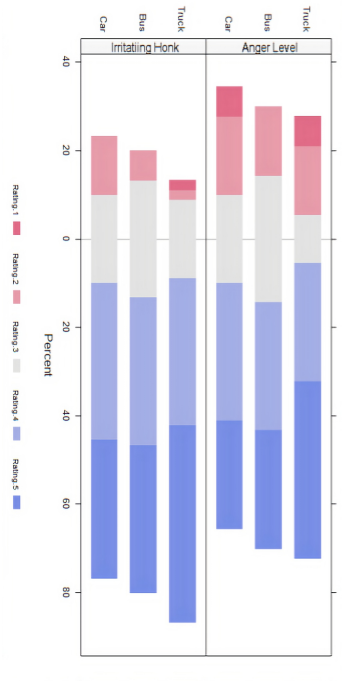

Figure 2: Rating on irritation levels and anger levels for honk type

interface physical steering wheel with controls was provided as the interface for the virtual car. Ambient traffic noise and sudden high decibel honking was provided by headphones. The dB varied from 40-80 dB (Frequency:150-400 Hz) for car, upto 110 dB (Freq:438 Hz) for Bus, and 119 dB (Freq:360 Hz) for Truck. Sensors were fitted on participants to record the pulse rate and GSR. Before presenting the three scenarios, the participants were administered a decibel test to check for individual noise level sensitivity and normalcy in auditory perception.

Results

Survey

A large percentage(46.9%) of participants (experienced and inexperienced) gave the highest irritation rating 5 for the truck honk, while around 26.6% (12 people) participants gave a rating of 4 for other honk types. On anger levels, the truck honk evoked the maximum in response while other honks were equally rated high (Figure 2). The self-report ratings indicate that honking does lead to irritation and aggravate a driver. We gathered extensive feedback about the VR simulator efficiency. The simulator was rated 5 (on a scale of 1-5, 5 being the maximum) by 29% of the participants, 4 by 46.67% and the remaining were distributed between a score of 3 and 2. Considering that a game simulator was used and many of the participants were experiencing a VR headset for the first time, the rating shows the simulator designed was an effective tool. On perceptive and qualitative parameters of the honking sound, 19.5% responded that loudness increased irritation, 3.6% said frequency and 43.9% stated that the combination of these factors affected them.

Behaviour Analysis

The behaviour of the participants was analyzed on his/her decision to either break the rule, move to an adjacent lane or give way to the trailing vehicle when subjected to aggressive honking. In 62% of the cases, the participants were confused due to the honking and showed visible signs of nervousness as head movement. They were noticeably anxious, and in 33% of all the cases, the participants broke the signal and crossed the red light. Out of the 43% of people who searched for free space on left and found it, 70% tried to maneuver their vehicle to give space to the trailing honking vehicle. The change in driver behavior (visible signs of nervousness) shows that honking driven anxiety can lead to undesirable traffic behavior and possible accidents.

Confirming by Consistency analysis

Figure 3 is a plot of individual participants for the three conditions from the inexperienced driver's cohort. A variance between honk type is observed in the GSR response, and it is consistent for all three conditions. That is, individuals with high GSR response in one condition show similar values for all three. Hence, ruling out the possibility of a random signal response. A similar trend is noticed in inexperienced drivers (Figure 4)

Skin Conductance Data Analysis

The GSR data related to the honking events were analyzed to study the probable effects of honking. In the time series GSR, peaks indicates the rapid change in skin conductance or perspiration, translative to sign of nervousness were identified. The behaviour decision was observed immediately after the honking, thus correlating to anxiety (measured by GSR/pulse rate values). To understand the relation between different vehicle honk (Car, Bus and Truck) and response in terms of GSR, user rating and observations, we performed a 3 (Vehicle: Car, Bus and Truck) X 3 (Measures: GSR, Rating, Observation Score) within-subject repeated ANOVA. The ANOVA results suggest that there is

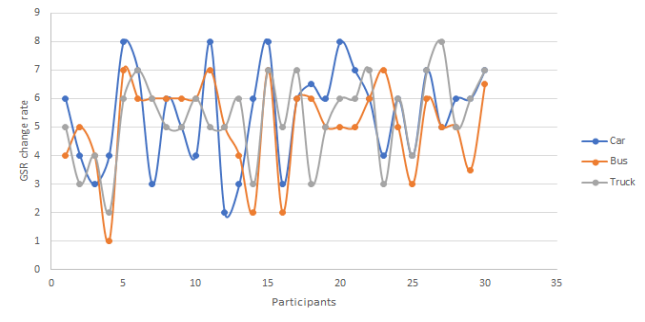

Figure 3: GSR change across inexperienced participants in case of (a) car (b) bus (c) truck

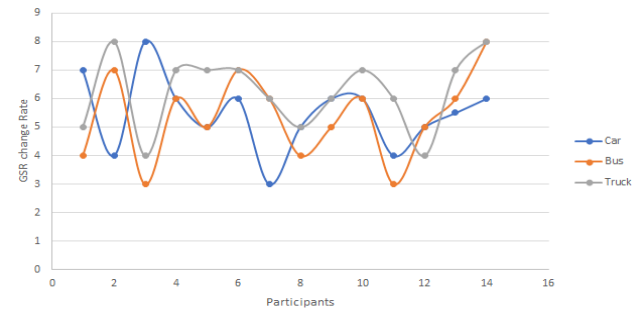

Figure 4: GSR change across experienced participants in case of (a) car (b) bus (c) truck

a significant main effect of a vehicle type ($F(2,84)=603.39$, $p<0.01$), pointing towards the differences across different vehicle condition.

Statistical analyses for significance between the experienced and inexperienced drivers was also conducted using a 2 sample T-test (paired at $p = 0.05$) to understand whether different honks creates different effects. The t-tests analysis was performed for (i) bus vs truck (ii) bus vs car (iii) car vs truck. A statistical significance ($p=0.042554$) for bus vs truck was seen for experienced drivers. In other two cases, there was no significance ($p>0.05$). In inexperienced drivers, significance was seen for bus vs car ($p=0.0453825$) and bus vs truck ($p=0.029251$) but in case of car vs truck, it was not significant ($p=0.07392$).

Correlation Analysis

Though it could be an ambiguous simplification to consider a physiological change of perspiration as a direct measure of anxiety/nervousness and hence the measurements must be correlated to the behavior data (self-report of irritation).

Structural Equation Modelling was done for relation between (ratings<–GSR) and (ratings<–Observation data). These relations comes out to be significant ($p<0.05$) in case of bus and truck but not is case of car ($p>0.05$). The positive results validates the initial hypothesis that high decibel and frequency honking can evoke significant anxiety/irritation (in case of bus and truck).

Discussion and Conclusion

The correlation values indicate effects of honking on the drivers' behaviour and anxiety , as inferred from the variable GSR values. The results also shows that driver's cognitive behaviour was affected substantially, due to high frequency and incessant honking of very high decibel. The pulse rate measurement did not show any change, a possible explanation could be awareness of a simulated environment rather than real life where fear would be an added factor. The correlation between the survey scores, behaviour data and skin conductance confirms personal experiences of irritation, nervousness and irrational decision under duress of the honking of the trailing vehicle.

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