Driver’s Aggressive Behavior – Experiments on the Driving Simulator

PETR BOUCHNER, STANISLAV NOVOTNÝ, DMITRY ROZHDESTVENSKIIY, JANA KADLECOVÁ, ANNA ČECHOVÁ, JAN SUCHÁNEK, JAN FLORIÁN
Department of Vehicles, Faculty of Transportation Sciences
Czech Technical University in Prague
Konviktská 20, Prague 1, 110 00
CZECH REPUBLIC
{bouchner|novotny|dima}@lss.fd.cvut.cz  http://k616.fd.cvut.cz

Abstract: - In 2013 a series of experiments was performed using the vehicle simulators available in the DSRG laboratory (Driving Simulation Research Group at Department of vehicles, Faculty of transportation sciences, CTU in Prague) to reveal the aggressive behavior stimuli at driving motorized vehicle principles. Scenes in scenarios were designed to continuously initiate a situation to provoke aggressive, inadequate or offensive behavior of drivers, the scenes from real scenery were used as well. The verification was performed on a group of drivers tending to behave aggressively.

Key-Words: - Driving simulation, Aggressive driving, Driver’s Behavior Assessment

1 Introduction
An aggressive behavior behind the wheel presents on of the major issues within the field of driving safety. Although this is a well-known fact there are quite few countermeasures which could be directly used to eliminate such behavior and its consequences. Study of drivers’ aggressiveness also suffers from lack of experimental data which could be used for investigation in drivers’ aggressive behavior principles, sources and consequences. Which could be in future used to detect such unwanted behavior and/or design the countermeasures. Our team started a research on this topic within a project ASLAN (Automatic watch of aggressive and dangerous drivers). In parallel with measurements on the real roads, we focused on safe laboratory experiments performed with use of the driving simulator and specially designed scenarios with a purpose to provoke “aggressiveness”.

As the whole problem of aggressive driving is very hard to handle, also driving simulator experiments are not frequently investigated and quite a few results have been published. It is most probably because of the fact that during the laboratory measurements the tested drivers tends to be much more responsible and respecting the rules then driving in their cars under normal conditions. From the literature study it is possible to say that the experiments on the driving simulators are mostly focused on subjective – questionnaire oriented measures ([2], [3], [4], [5], [6], [7]). Some experiments incorporated a set of situations which the drivers have to evaluate upon the scale of aggressiveness. Drivers were for example [3] asked before and after experiment whether the drivers consider such situations as aggressive and if they encounter and/or do them in reality. Some studies also incorporated psychophysiological measures like blood pressure and heart beat frequency [3], or scanning of drivers’ actual sight- eye tracking [1].

Usually results of the experiments approved that aggressive behavior can be successfully measured with use the driving simulators ([1], [3], [7], [5]), but also did not brought too much real results. In conclusion the most important factor seems to be a kind of scenarios. These had each different traffic density (congestion, smooth traffic, moving interference - no congestion). When the scenarios are set up correctly an aggressive driving was indicated by more acceleration changes, speeding and more collisions [1].

Experiments were performed on various types of driving simulators and it is not possible deduce whether its type (steady based, motion based, large scale projection etc.) or parameters have influence on results. From our experience, the quality of a simulation must be on a high level, since a driver must immerse into driving more than in case of other kind of experiments. The field of view must be as large as possible because the driver should perceive stimuli from around and cockpit and the vehicle responses (feedbacks) should be close to reality. On the other hand a lack of the motion platform did not caused problems with simulator acceptance.
The proposed experiments must be designed to be robust, enabling, even in the laboratory, to find evidence of aggressive behavior as in the real situations. Form this point of view one of the most interesting experiments was performed in [8], which gave an inspiration to experiments described hereby. Authors built up the scenario based on several cross-sections, where particular drivers had to wait for a green signal for prolonged times and some of them behaved aggressively, some even violated traffic rules.

2 Vehicle Simulator in Experiments
This vehicle simulator is dedicated to the simulation of driving under real conditions similar to those of Czech roads. The design is based on, so called, light constructions of interactive simulators, the cabin of which consists of real vehicle parts that surround the driver. The simulator cockpit was built using the parts of a middle-class vehicle with automated gearbox or shift, fixed to the simulator body. There are three projection screens forming a half-cubicle, the cockpit with the driver is located in the middle („half-cave system“). Its horizontal extent covers the driver’s view in 270 degrees. The rear mirrors are designed in the appropriate part of the projection system (Fig. 1).

Fig. 1: The vehicle simulator in use (driver’s view)

2 Virtual track description
The development of a scenario for an aggressive behavior aspects investigation, respected certain requirements - the scenario shall provide the stimuli to react in an aggressive or dangerous driving.

A driver passes through an urban area with radial network of roads (see Fig. 2). There are two circles of communications in the town layout, one with smaller and second with bigger radius (they are not circular).

Fig. 2: Virtual track scheme

2 Description of the scenario to provoke aggressive behavior
Each scenarios presents a single specific situation. As the scenarios for most of the situations are created separately, the database needs to be formed to hold the already modeled scenarios with connection to variable events. All required events are called up by a trigger (invisible object placed within the scene) that is incorporated in the event according to the specific need. On passing it, the respective event is called up. The traffic or other animated objects are switched on using the triggers and the signal plan of the crossroads can be changed, too.

The elementary idea of stimulating aggressive behavior of a driver is this situation: The driver is the first in a line at a traffic lights and the red signal “STOP” is active. According to the regulations, he is not allowed to enter the crossroad. At the moment when the light is changed to „Go!“ and the driver could enter the crossroad, he is not allowed to as the cars crossing the road from in perpendicular direction occupied the crossroad. This situation lasts for the whole period of “Go!” signal until it’s changed to “Stop!”. At that moment, the driver is again not allowed to enter the crossroad and has to wait until
new “Go!” signal. Such a situation is then repeated (see following pictures - Fig. 3, Fig. 4).

Fig. 3: The line blocking the crossroad - scene 1

Fig. 4: The line blocking the crossroad - scene 2

5 Process of Experiment

The participants in the experiment were active, non-professional drivers. They all were aware of driving vehicle simulator and possible aggression signs during driving would be observed. Each driver was asked to fill in a questionnaire, consisted of questions about their: age, sex, kilometers driven per year, if the driver is seen as aggressive by the public and what type of roads does he use.

The experiment started with the warm-up drive on the training circuit. The drivers could test the sensitivity of simulator controls, especially the steering wheel feedback. After this test circuit, the drivers were equipped with measuring devices such as the Eye-Tracker (sight control device) of EEG (central neural system activity measurement device). All the procedure was structured in two parts. One half of experimental drivers had the mobile Eye-Tracker on (Fig. 5). The second half of drivers was measured by distance Eye-Tracker (the cameras are fixed in the interior of the cockpit) and the EEG record for further analysis was taken by the electroencephalograph.

During the ride, participants were navigated by green arrow indicators located under rear mirror. The procedure of driving under the scenario was performed the following way:

- Driving along the small circle with traffic lights on crossroads
  - The driver, leaves the southern end of the town goes in northern direction, first to the crossroad where he turns right towards the small circle. Here he/she encounters three crossroads with traffic lights, at the third he leaves the circle to the right. He/she follows the connection between both circles and at the traffic light he/she gets to the large circle.

- Driving along the large circle with crossroads controlled by traffic lights (prepared scenes)
  - The situation described above (the crossroad is blocked by a line of cars going in the crossed direction) happens at the traffic lights on the large circle. The aggressive reaction was measured in these points. The large circle is circumnavigated more than once i.e. the situation reappears several times.

The driving direction is marked on virtual track description on figure 2.

After the drive, the driver underwent the final questionnaire. He/she was asked about the situations during the ride, whether he/she consider them real-like, whether these stimulated the nervousness or physical discomfort and the lastly they were asked about the signs of aggressive behavior that he met in real situations and how frequent these signs were. The scale for evaluation was set in extent from 1 – 5, where 1 = never, 2 = once a year, 3 = once a month, 4 = once a week and 5 = every day. The driver was furthermore asked if he/she sees the signs as aggressive and if he/she himself/herself keeps behaving this way.

Fig. 5: The mobile Eye-Tracker device setup
6 Measured Data

The measured data carries an information about the driving style and all driver’s reactions, related to the driving. This information is automatically recorded when the simulation starts. Further data was recorded with Eye-Tracker (mobile or distant). In case of distant Eye-Tracker (see Fig. 6) additionally the, psychophysiological data was recorded. These reflect the current state and condition of a human body (EEG recording).

![Fig. 6: Distant Eye Tracker use](image)

7 Group of Test Drivers

There were 30 drivers altogether (3 women and 27 men). The age of drivers varied between 20 – 36 years. Results and data of only 19 drivers could be used for further analyses, as so called simulator disease appeared at others. It’s a frequent complication that occurs during driver’s training or experiments on simulators. More sensitive persons can suffer from sickness if they are driving in the simulator. This unpleasant phenomenon is quite often discussed in literature and possible causes are seen in poor synchronization of picture and movement, missing or wrongly interpreted movement impressions. The drivers who felt sick during driving had to cancel the experiment or pause the activity, therefore the results were not usable for further analyses.

8 Technical Data Analysis

The behavior of tested drivers at the crossroads, where the pre-selected scenario was applied, can be divided into several groups (abbreviations correspond to those used in the pictures):

- **SC** – Correct behavior, without aggressive hints – the driver waited until the crossroad was free to be crossed and continued on green, “Go” signal.
- **OK** – Entering the blocked crossroad – the driver enters the crossroad on “Go” signal, but the free throughput is not granted and the crossroad was blocked by cars, forming a line in the perpendicular direction.
- **ZB** – The driver entered the crossroad on combined signal red/yellow („Ready!”) – The signal with both lights on. This signal only gives a warning to prepare for the drive.
- **O** - The driver goes round standing vehicles in perpendicular direction – the driver provoked dangerous situation by entering blocked crossroad.
- **CB** – The driver enters the crossroad on „Stop“ signal – It indicates the obligation to stop the vehicle before the transverse line, if the line is not there, in front of the lights. The driver still enters the crossroad.

The following chart (Fig. 7) shows the histogram of tested drivers’ behavior at crossroads. It shows the graphic data distribution using column chart, the height of bars indicates the frequency of observed value in the given interval. We can read there, that 35% of the drivers acted properly at the crossroads. On the other hand almost 40% of all the demonstrations belonged to the second group, i.e. the driver entered the blocked crossroad on combined signal yellow/red.

![Fig. 7: Histogram of driver’s behavior at the crossroads](image)
The following set of pictures shows the user interface of newly created analyzing tool. The individual pictures show the observed examples of improper or aggressive behavior at the crossroads.

**The OK version** – driver enters the crossroad on “Free” signal, but the secure crossing is not possible as the center of the crossroad is blocked by vehicles in perpendicular direction. It is possible to be seen in the picture of analyzing tools (see Fig. 9).

**The ZB version** – the driver enters the crossroad when the combined signal is active (red/yellow) signaling the driver should be ready (Fig. 10).

**Version O** – The driver goes round blocking vehicles that are located in the perpendicular direction. Although it gets into the crossroad when the signal is “Go”, performs quite difficult maneuver (Fig. 11).

**Version CB** – The driver enters the crossroad when the signal “stop” is active – the reason can be the frustration based on several minutes of waiting due to the cars in the perpendicular direction – (the crossroad was free at the entry but the clear out was performed after the signal was changed to „Stop“), see Fig. 12.

9 Conclusion
To perform these specific experiments, new scenarios for vehicle simulator were created and implemented. They were designed to provoke aggressive, improper or offensive driver behavior. The scenarios were tested and tuned in pilot tests. The simulator was equipped for a new set of experiments
(Vehicle simulator to Eye-Tracker communication and EEG was set, especially for data exchange). Altogether there were 30 drivers in the test. Only 19 could have been used for further analyses, because many participants suffered from simulator disease. The data was properly processed and analyzed. It can be said at the end there are more than 60% of improper up to aggressive solutions to the assessed situations. Some drivers even committed serious traffic offenses (driving on the „Stop” sign). However, most drivers felt themselves as non-aggressive in the initial questionnaire. The scenario fulfilled its aim and was able to provoke aggressive behavior. Additionally there was created an alternative scenario in which the driver should circumnavigate a stand-by vehicle. The car going parallel in left lane doesn’t allow him to do so. The assessment of the experiment was performed on specially created analyzing tool.

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References: