THE IMPACT OF SUDDEN DETERIORATION IN WEATHER CONDITIONS ON ROAD SAFETY

Sudden deterioration in weather conditions can cause dangerous traffic events. In 2014 there was over 3,200 road accidents during rain on Polish roads and about 500 took place in the presence of snow or fog.

The paper presents a study of concentration changes during simulation training of drivers carried out at the Institute of Internal Combustion Engines and Transport at Poznan University of Technology. With the use of a technically advanced passenger vehicle simulator AUTOSIM AS1200-6 and the bioelectrical brain activity monitoring device MindWave produced by NeuroSky it was possible to determine the effect of a sudden deterioration of weather conditions on the concentration of the driver. Studies have shown that for the majority of respondents a sudden change in weather conditions strongly influenced the level of concentration of the driver.

Keywords: road safety, driver’s concentration, simulator, MindWave, EEG

1. INTRODUCTION

Studies of the World Health Organization indicate that road accidents are now in 7th place on the list of the greatest threats to human life and health. For 25 years they will be the second, after hearing diseases occurring on a background of neurotic. These indeed are caused in part noise caused by transport. European Road Safety Council shows as follows effects of the whole transport system on the lives and health of citizens [3]:

- 1 of 3 European Union citizens will be hospitalized because of participation in a road accident,
- 1 of 20 people will die or be seriously injured in a road accident,
− 1 of 80 people will end their lives by 40 years earlier because of a traffic accident,
− average life of EU citizens is shortened by six months because of road accidents,
− in contrast to other causes of death, road accidents cause deaths mainly young people,
− road accidents cause the greatest number of premature deaths from external causes.

Improving road safety is possible by working in two main areas. The first of these concerns technical issues, i.e. the improvement of vehicle active safety and improve the quality of roads. The second area concerns the work to reduce the impact of human error. To important issues in this area include: education, training and examination of driver’s psychophysical condition.

2. RESEARCH METHODOLOGY

2.1. The Simulator AS1200-6

The research was conducted using a vehicle simulator AS1200-6 produced by AUTOSIM company. The simulator was developed based on the actual full-size vehicle cab from Lancia Ypsilon. The use of the real body of the vehicle allows to reproduce the driver's workplace, taking into account its ergonomics and feelings leading vehicle as close as possible to the actual. The cab is set on a hexapod, which allows to create simulator with six degrees of freedom. Additionally, the device is equipped with a spherical screen projectors that allows for visualization of the field of view (FoV) with a value of 220 degrees, which means that the driver while driving does not see the edge of the screen, only moving up to the speed computer-generated scenery (trees, buildings, road infrastructure, people, etc.) [9]. Visual quality is realized by changing the image at 60 Hz when using the normal mode. At very high load (traffic density and a comprehensive visual database) the minimum frequency is 30 Hz. The delay control reaction occurs in less than 50 ms, the mobile platform delay is lower than 10 ms [5].

During the simulation parameters such as acceleration, position of the accelerator, brake and clutch, the position of the gear lever, steering wheel, direction indicators, horn and handbrake can be accessed [6].

The device makes it possible to simulate the visual effects [9]:
− the movement of other vehicles on the road,
− the movement of pedestrians and cyclists,
− rainfall,
− snowfall,
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− snow on the ground,
− fog,
− day- and night light.

Advanced visualization allows for recreation of the driving conditions similar enough to the real conditions that it gives the driver the impression that he is driving a real car. The simulator is shown in Fig. 2.1.

Fig. 2.1. Simulator AS1200-6 [2]

2.2. Device for measuring the bioelectric activity of brain

Investigation of bioelectrical brain activity was performed using a MindWave device, which is manufactured by NeuroSky. The device was released in 2010 in China and 2011 in the US and the EU. The MindWave uses the principle of the conventional electroencephalograph, but through the use of simplifications and applications is much more affordable and easier in exploitation. The MindWave Mobile safely measures and outputs the EEG power spectrums (alpha waves, beta waves etc.) [7]. The signal measured by a device is amplified and converted from analog to digital by the converter with a sampling frequency of 512 Hz [1, 2]. In the basic version of the device measures three values: raw EEG signal, the level of concentration and the level of relaxation [1, 8]. MindWave is equipped with a dry scalp electrode (called Fp1 according to the international standard 10-20) and the reference clip mounted on the ear. Thanks to the simplified construction usage is much easier than with traditional methods. Mindwave does not require, in contrast to the conventional device, the application of conductive paste. Equipping Mindwave resembles putting on a mobile headset. The device is based on Bluetooth,
thereby using it is not limited in any mechanically way. A product of NeuroSky is powered by a single AAA battery, which allows for 6 to 8 hours of continuous operation. Fig. 2.2 shows the device (a) and how it fits on a person’s head (b).

Fig. 2.2. The mindwave device (a) and how it fits on a person’s head (b) [12, 14]

2.3. Devices measuring reaction time

Piórkowski Apparatus – AP (Fig. 3) is used to study the psychomotor reaction speed and hand-eye coordination. The device is widely used in occupational and transportation psychology [4]. The apparatus consists of a test keyboard, a microprocessor control panel with LCD display, a power unit and a connection cable. The keyboard consists of 10 buttons located under 10 signal lamps. The control panel is used to adjust the test parameters (test duration, stimulation frequency). The settings of the apparatus and results of individual tests, including the number of correct responses, the number of incorrect responses and number of stimuli ignored, as well as the mean, minimum and maximum reaction times, and the percentage of correct responses are displayed on the LCD screen.

The test consists in individual lamps being lit at a steady, predefined pace. Lamps go off before the next lamp is turned on. The task of the subjects is to press the buttons corresponding to the lamps being lit in a possibly fastest and possibly most accurate manner. The study subjects perform the test in standing position using both index fingers.

For the study described in this article assumes 60-second test with a frequency of 100 stimuli per minute.

The device allows measurements of the following parameters:
– the number of reactions: correct, incorrect, omitted;
– response time: average, minimum, maximum;
– efficiency expressed as a percentage of correct answers.
Due to the subject of the article average, minimum and maximum response time were analyzed.

The MPR apparatus allows to measure response time to the produced audible or visual stimuli.

During the measurements the random stimuli are transmitted using different signals. On the panel there are three colored LEDs: red, yellow and green. They are also used sounds of low or high range. Correct responses to stimuli are:

- red light – the left hand bottom,
- light yellow – the right hand bottom,
- light green – the left foot pedal,
- bass – the right foot pedal,
- treble – both pedals at the same time.
2.4. The course of study

The study lasted for approx. 40 minutes, including 20 minutes of simulator training. Prior to the training, as well as after its completion, examined performed test using Piórkowski Apparatus and MPR apparatus (reaction time meter).

The initial eight minutes of simulator training was intended to familiarize with the simulator and preparation examined to proceed. The main part of the study aimed to investigate the driver's concentration changes depending on changing weather conditions, there was a period between 8 and 11 minute simulator training.

After 8 minutes, instructor change the simulator settings giving the fog effect, which limited visibility to approx. 50 meters. Then, after one minute restored to its original settings, including good weather conditions. In tenth minute, instructor activate the rain effect. A device for measuring bioelectrical brain activity was running throughout this period. Changes of atmospherical conditions during the test are shown in Table 1.

<table>
<thead>
<tr>
<th>Minute</th>
<th>Situation</th>
<th>Weather conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>a standard ride</td>
<td>good</td>
</tr>
<tr>
<td>8</td>
<td>the beginning of the fog simulation</td>
<td>bad</td>
</tr>
<tr>
<td>9</td>
<td>the end of the fog simulation</td>
<td>good</td>
</tr>
<tr>
<td>10</td>
<td>the beginning of the rain simulation</td>
<td>bad</td>
</tr>
<tr>
<td>11</td>
<td>the end of the rain simulation</td>
<td>good</td>
</tr>
<tr>
<td>12</td>
<td>a standard ride</td>
<td>good</td>
</tr>
</tbody>
</table>

The purpose to examined was a continuous drive in accordance with road traffic regulations. The scenario chosen for the study included both urban cycle and sub-urban cycle.

Map used for the tests is shown in Fig. 2.5. In the upper leftcorner is shown the panel which presents possible to determine the effects of rain or snow with an intensity. In the lower left corner is a panel relating to the fog effect for selecting the quantitative determination of impede the view. In the top right corner is presented panel which allows to control the parameters wind. It is possible to change wind direction and speed, but it was not used during the tests.
3. RESULTS

3.1. Reaction time

Evaluating the reaction time of psychological aptitude tests is one of a set of tests performed in the laboratories of psychological an overall assessment of the ability of a driver to drive mechanical vehicles.

Reaction time consists of [1]:
- stimulus reception time,
- perception (time of admission to consciousness)
- identification (define),
- reaction.

In the other sources response time is defined as the sum of the so-called. Mental reaction time and motor reaction time (physical) [4, 5].

The psychological reaction time is understood as response time on the accelerator pedal (time since the obstacles is launched for the start of removing feet from acceleration pedal). It occurs before a physical reaction to a stimulus. In this time the operator decides to act or lack thereof. The physical reaction time is counted from the moment of taking action, e.g. usage of brake pedal (or button in Piórkowski apparatus).

Typically, the transition from one to another reaction time is automatic and there is often a problem with the differentiation. For the purposes of the said method adopted that psychomotor reaction time is the sum of the above-described reaction times (mental and physical).
The purpose of this studies was to answer the question of whether simulator training influences the change of average reaction time. Figure 3.1 presents a summary of the reaction time obtained before and after exercise in a driving simulator.

![Fig. 3.1. Reaction time obtained before and after exercise in a driving simulator](image)

The research confirmed the thesis, that the simulator training has beneficial effects on reaction time. In both – the test using the Piórkowski apparatus and the MPR apparatus – the reaction time after the simulator training is shorter than reaction time before training. Average reaction time after training, obtained with a MPR apparatus, was over 30% shorter. In the case of the maximum and minimum reaction time the results get improvement of approximately 20%.

![Fig. 3.2. Ratio of correct, incorrect and omitted responses:](image)

- a – before training (Piórkowski apparatus),
- b – before training (MPR apparatus),
- c – after training (Piórkowski apparatus),
- d – after training (MPR apparatus)
Another important value is the ratio of correct, incorrect and omitted responses. Based on Piórkowski apparatus, before simulator training there was a 92% correct answers (Fig. 3.2). After training the value of correct answers increased to 96%. For the MPR apparatus the difference between the results amounted 10%. Before training 73% of answers was correct, after training this number growth to 83% (Fig. 3.2).

3.2. Concentration

The data obtained from the test were collected in a recording-research sheets. MindWave device records to the sheet three values: raw EEG signal, the level of concentration and the level of relaxation [10, 11]. For the purpose of analyzing changes in the driver’s concentration only value of concentration level is used. Its defined as attention. Figure 3.3 contains a detailed analysis of test results. Red dotted lines marked the points, where the sudden deterioration in weather conditions occurred.

The first 60 seconds is characterized by a variable level of concentration. However, after one minute, when instructor change the simulator settings giving the fog effect, which limited visibility to approx. 50 meters, the level of driver’s concentration sharply decreased. This situation lasted only a few seconds and was caused by the fact that examinated was surprised. He was not prepared for the changes of conditions. It should be noted that the so-called the initial shock, the concentration level starts to rise – examined knows that in order to properly complete the task must concentrate and his reactions must be correct. After about 30 seconds driving with limited visibility, occurs a decrease the level of concentration caused by habit to the situation. It is observed till the end of second minute. The increase of level about 2nd minute of measurement is caused by return to standard settings (good weather conditions). Any significant change in the simulation reality surrounding the driver is not irrelevant to the level of his concentration.

Another key moment is the 180th second of test, when the instructor change the simulator settings giving the intense rain effect. The decrease in concentration was much more intense than in the case of fog. However, similarity can be seen in the fact that, as previously after the “initial shock” level increased until the next change, which was a return to the initial, good weather conditions (approx. 240th second of the test). After the termination of all impediments, level of concentration remained consistently high. Momentary hesitation about 4th minute (290th second) can result from measurement error or for other reasons, such as the unexpected emergence of another vehicle on the road.

Concentration, in relation to road traffic, should be understood as mechanism that reduces information overload. It is a process inseparably accompanying the
processes of the nervous system. The level of concentration, relaxation or overload is therefore individual matter.

![Fig. 3.3. Changes in driver’s concentration during simulator training](image)

4. SUMMARY

The research presented in this paper have shown that it is appropriate to conduct simulator trials that could improve capabilities of drivers. With the simulators, drivers can check their reaction to situations often impossible to train under real traffic conditions. This may be eg. a flat tire which can cause worse steering control and which could lead to dangerous traffic incident. Different dangerous situation may be a sudden deterioration in weather conditions.

The research shows that simulator training influences to the change of reaction time. The studies included reaction time to the stimulus indirectly related to the situation of road. The reaction time was recorded before and immediately after simulator training, not during an emergency. It has been proven, by using two apparatus, that the reaction time after the simulator training is shorter than before.

Research on changes in driver’s concentration showed a high correlation between the attention and the sharp deterioration in weather conditions. It was noted a change in the level of driver’s concentration within the 6th and 8th minute, ie. at moments of deterioration in weather conditions. After a temporary decrease, it was observed subsequently increase in the level of concentration. This may be caused by processes associated with getting used to the situation by examined and somehow familiarize himself with the device. This situation lasted until the occurrence of the next significant change in the simulation.
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Studies using simulators can be of key importance especially for professional drivers, which eye-hand coordination, especially the reaction rate and concentration skills are the key for the implementation of transport tasks in special conditions and in the presence of emergency. Demands increased concentration and focus is also required in other industries, but in the field of transport may have an impact on the health and lives of many people.

Thanks to modern solutions it is possible to study the changes in level of concentration, reaction time, etc. without compromising on direct threat to health and life, which would inevitably happen if research in real traffic conditions.

An additional advantage of this type of research is the ability to reproduce the same conditions for a greater number of examined, which would be impossible in the real traffic.

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BADANIE WpływU NAGŁej ZMIANy WARUNKÓW ATMOSPHERYCZNYCH NA BEZPIECZENstwo RUCHU DROGOWEGO

Streszczenie

Nagle pogorszenie warunków atmosferycznych może powodować występowanie bezpiecznych zdarzeń drogowych. W 2014 roku na polskich drogach odnotowano ponad 3200 wypadków drogowych w czasie deszczy, a około 500 podczas opadów śniegu lub podczas mgły.