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Analysis of selected off-road glances during driving in real road traffic

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Abstract

The aim of this ongoing research has been the analysis of driver visual behavior in real road traffic. The paper deals with analysis of duration of selected off-road glances. The total gaze duration depending on mirror type has been analysed and also the total gaze duration depending on the navigation task type. For the purpose of this study eye-tracking technology has been used. Eye-tracking method is used to measure motion of an eye relatively to a head. The total gaze duration depending on mirror type has been analysed and also the total gaze duration depending on the navigation task type. The average value of total off-road glances regarding to the checking situation in vehicle mirrors is 1,2 s. The glance frequency distribution shows that the drivers used the right rear-view mirror minorly. As evidenced by the obtained results, the total off-road glance time on the navigation system is dependent on the type of the navigation task. The average value of total off-road glances regarding to the use of the navigation without audio information is 0,9 s, with audio and video navigation system is the average off-road glance time 0,6 s.

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1. Introduction

Distraction and inattention have been considered as one of the most often factor leading to the accidents. Driver could miss significant information due to the high density of information in road traffic as well as due to the interaction with vehicle systems, etc. The National Highway Traffic Safety Administration (NHTSA) issued a set of voluntary visual-manual distraction guidelines for in-vehicle electronic devices [1]. The guidelines quantify visual-manual demand in terms of objective visual behaviour. The NHTSA guidelines has been based on previous Alliance of Automotive Manufacturers guidelines. The main difference between these two guidelines is the definition of off-road glance – NHTSA consider as off-road glance every glance not directly focused on road (included task related glances as checking speed or vehicle mirrors). Compared to that the Alliance of Automotive Manufacturers guidelines considered only glances associated with in vehicle devices.

The aim of this paper is analysis of selected types of off-road glances. As driving related task, checking the vehicle mirror has been chosen. Compared to that, as a type of driver distraction, the navigation system glances has been analyzed.

1.1. Navigation systems

Navigation system are one of the most often information system widely integrated in vehicles. Even thought, using of navigation lead to the road traffic improvement (less time spend in traffic), using of this system could be distracting. Distraction caused by navigation systems could be physical (typing the address), visual (fixation on the navigation monitor), auditory (listening the instructions) as well as cognitive (focus on the instructions). The analysis of negative influence of navigation systems on driver attention has been analyzed by number of studies. Tijerina [5] analyzed the influence of navigation type. Three visual – manual systems and one voice system were analyzed. Visual – manual system required longer time for the destination entry compared to the voice navigation system, these systems were also associated with longer off-road glance times. The influence of navigation system on driver reaction time was analyzed by Harms [3]. For the purpose of this study the peripheral detection task was used. Using of navigation system led to the reduction of driver performance. In [6] visual demand involved by display position were analysed. Author used two different versions of detection response time method. visual demand was higher when participants operated with the display in the low position rather than in the high position and driver reaction times were slower. Also the analysis of the influence of navigation display size was studied. Jahn [4] selected two navigation types – navigation with small display (5.9 x 3.1 cm) located in the radio slot and a large-screen color navigation located in the holder. 49 professional drivers (average age 41.2 years) participated in the study. The influence of the display size on driver attention tested with PDT has not been demonstrated. As evidenced by Chiang [2], during using of navigation system, drivers try to compensate distraction. Speed reduction was observed, when entering the route to the navigation.

1.2. Vehicle mirrors

The driver behavior during the checking of the situation behind the vehicle have been widely studied by a numerous studies. Some of the studies analyzed the total percentage of selected action compared to the total length of the route, the percentage, e.g. Harbluk [12]. Regarding to the NHTSA recommendation that the total off-road glance longer than 2 s two times increased the crash risk, also there has been a number of studies focusing on a length of single glance behavior. Some of the studies analyzed only the fixation on the selected types of the vehicle mirrors. The total off-road glance behavior include also the glance transition, so some of the studies analyzed also the total off-road glance time. The group of studies focused only to the total fixation in the vehicle rear mirror reported the average values about 0,5 s (e.g. [13],[14]). Compared to that the group of studies focused to the total off-road glance time (included the glance transition) reported the average values about 1 s (e.g. [11][10]).

2. Methods

For analysis of glance duration, eyetracking method have been used. Eye-tracking method is used to measure motion of an eye relatively to a head. The purpose of the eye movements is to fixate objects in the field of a view, in the area of sharp vision (foveal region). As shown in [14], fixation analyzation is a eligible method of minimizing the complexity of eye-tracking data while retaining most essential characteristics for the purposes of understanding cognitive and visual processing behaviour. For the purpose of this study, the video-based eyetracker has been used. This type of device combines a video images and a pupil reflection exploiting an infrared light. An infrared light is shone into the eye and then it is reflected from the lens and sensed by a video camera [6].

The measurement was carried out under real condition in normal city traffic. The total route length was 16 kilometres. All participants in this study were free of medical and cognitive impairment. For the purpose of this study, the distraction caused by using of navigation system was analysed. Two types of tasks were analysed – only visual information and combination of visual-auditive information. Drivers were instructed to follow the direction of the navigation system. Compared to the distraction also one of the most frequent driving-related off-road glances were analysed – checking the situation behind vehicle in the vehicle mirrors.

For the purposes of this study, only individual glances were analysed. As a single glance was taken every situation where the driver looked away from the road toward to the analysed object (mirror, navigation system), fixation to the analysed object and returning of the glance back to the road.

3. Results

For the purpose of this study, the total glance time (included the glance displacement from roadway as well as the fixation). The obtained results were analysed separately. The total gaze duration depending on mirror type has been analysed and also the total gaze duration depending on the navigation task type.

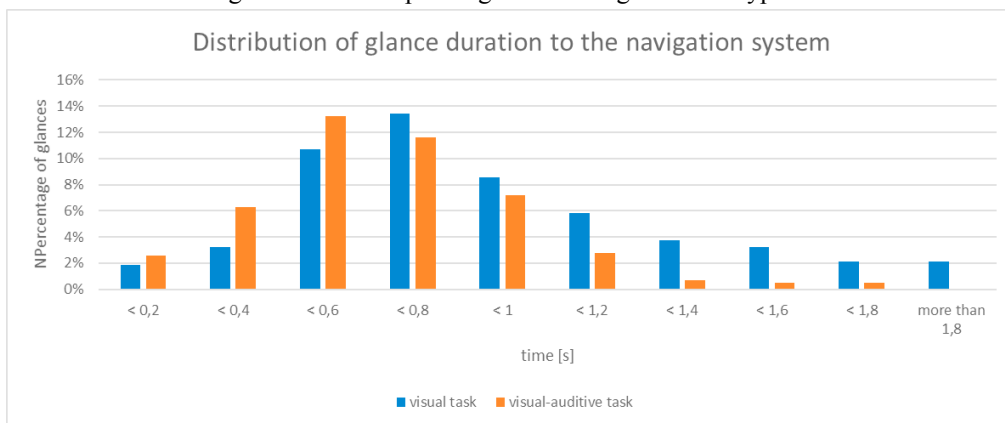


Fig. 1. Distribution of gaze duration to the navigation system

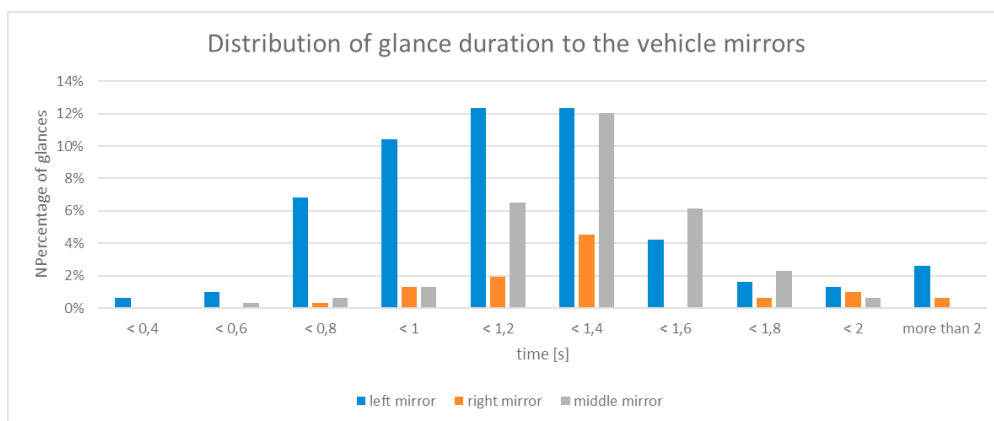


Fig. 2. Distribution of gaze duration to the vehicle mirrors

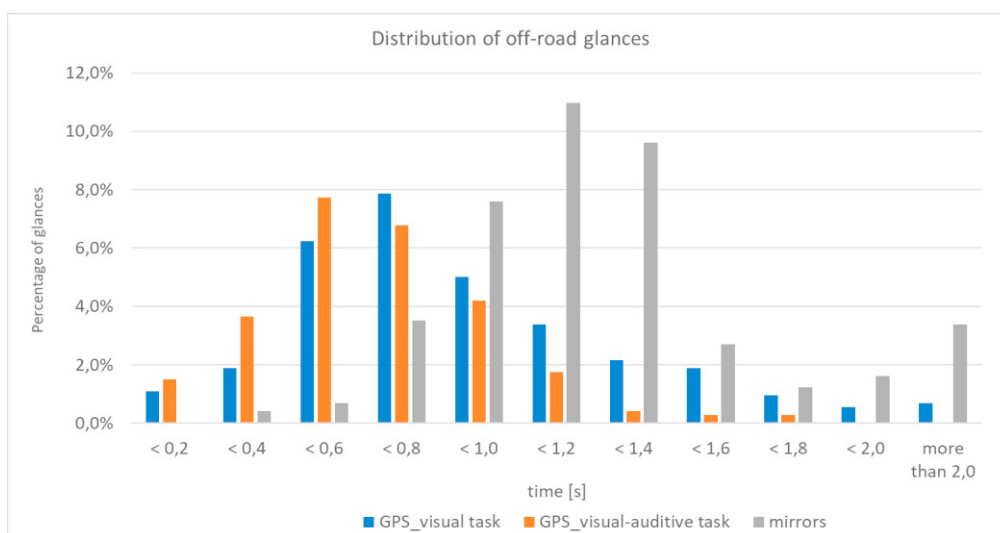


Fig. 3. Distribution of off-road glances

Distribution of total gaze time is not normal (Gaussian) in both tasks. The obtained results of off-road glances depending on mirror type were compared using nonparametric Kruskal-Wallis test. This test indicated not statistically significant differences between the types of mirror. The average value of total off-road glances regarding to the checking situation in vehicle mirrors is 1,2 s. The glance frequency distribution shows that the drivers used the right rear-view mirror minorly.

Also the total off-road glance time depending on navigation type task were analysed. The Kruskal Wallis test indicate statistically significant differences ($p = 0.00$). The total glance time (the total off-road time including the fixation to the navigation system) has been statistically significantly higher when the combination of the audio and video navigation is not used. The average value of total off-road glances regarding to the use of the navigation without audio information is 0,9 s. The average value of total off-road glances regarding to the use of audio and video navigation system is 0,6 s.

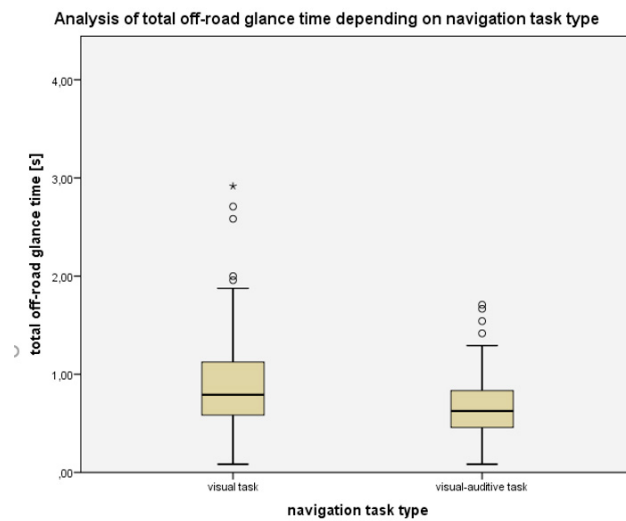
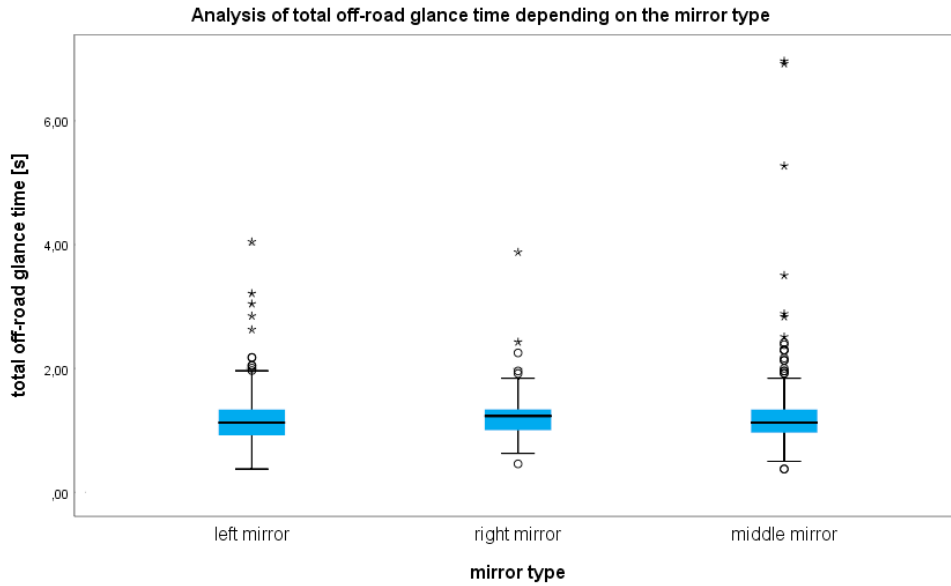


Fig. 4. Total of road glance time depend on vehicle mirror type (a) navigation task type (b)

4. Discussion

The preliminary study results also showed that glance detaching off the road is longer if the situation behind the vehicle is checked compared to the use of navigation system. While using of the navigation system is a distraction and has been perceived by driver as a distracting, for the control of the situation behind the vehicle has been necessary to take a look off-road, but whereas this is an action related to the driving, it has not been perceived as distractive or risky. The results may also indicate that checking the situation behind the vehicle could be for driver a

more difficult action compared to the route navigation.

The average glance duration on vehicle mirrors was two times higher compared to the Morris [8] study. The obtained results are comparable with the results reported by Wierwille and Rockwell [11], [10]. In both of these studies were included also the glance transition from the road as well as in this study. In Sodhi [9] was only 2 off 95 off-road glances during rear-view mirror task exceeded 1,6 s threshold and the largest off-road glance was 2.02 second. Compared to that, in this study, the maximum off-road glance related to the rear-view mirror was 6 s long and 20 % of glances exceeded 1.6 s threshold. The mean total off-road glances related to the audio-video navigation system has been lower compared to the study Morris [8]. In this study was analysed only the audio-video task, so the comparison of the audio task only is not possible. Morris study also reported that there were very few glances higher than 2 s.

In order to eliminate the results distortion and confirmed the obtained assumptions, the number of participant should be increased. Furthermore, the influence of the selected driver characteristics on the obtained results could be analyzed, e.g. driver experience, age, road familiarity.

Conclusion

The aim of this paper has been the analysis of driver visual behavior in real road traffic. Visual distraction has been reported as the most dangerous type of distraction because most of the stimuli in the road traffic has been perceived visually. One of the advantage of this study has been the realisation in the real road traffic, because some of the studies shows that in simulated condition could be results distorted by the sense of safety. Drivers were simultaneously exposed to the various types of critical situation e.g. suddenly entering of a pedestrian into the road on the pedestrian crossing. Headlund [7] define distraction as a diversion of attention from driving on an object or task not related to driving which reduces awareness of driver and leading to the increased risk of accident or near-accident. Distraction guidelines of NHTSA proposed some recommendation for the distraction elimination as reduce the task complexity and limit individual off-road glances required for device operation to less than 2s. Glances longer than 2s increase accident risk two times than normal driving [8].

As evidenced by the obtained results, the total off-road glance time on the navigation system is dependent on the type of the navigation task. It could be concluded, that with regard to the road safety, the use of the navigation system with both (audio and video navigation) is less distractive. Using the combination of the audio-visual navigation task requires a shorter off-road time. Comparison of the total off-road glances while using navigation system with analysis of the situation behind the vehicle in the vehicle mirrors shows that the time necessary to check behind the vehicle is higher. The obtained results could be used not only for the purpose of forensic examination in the field of the accident analysis, but could be beneficial also for the drivers education in order to improve road safety.

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