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DEGRADATION OF THE PERFORMANCE OF ROAD VEHICLE DRIVERS DUE TO THE INFLUENCE OF CABIN DISTRACTIONS

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Abstract: *Performing multiple tasks simultaneously can have negative impact on driver performance, including on the occurrence of traffic accidents (TA). Possible negative influence of the cabin distraction factor on the performance of road vehicle drivers will be investigated. The most dangerous is the writing text messages on a mobile phone while driving. Also, effect of using a cell phone while driving on a driver's performance is the same regardless of whether the driver holds a cell phone with his hand during a conversation or not. Raising awareness of the negative consequences of distraction and, the development of advanced vehicle system is needed to reduce the growing proportion of such accidents.*

Key words: *road traffic, driver's performance, cabin distraction, traffic accident, mobile phone.*

1. INTRODUCTION

The performance of road vehicle drivers can be negatively affected by several factors from the work and traffic environment at the same time. The dominant factor in the degradation of performance in recent times is the distraction of drivers. More and more drivers perform multiple actions at the same time while driving (e.g., use of smart phones, consumption of food and beverages, smoking, talking to the passenger, etc.). Also, there is an intense increase in the proportion of TA that are thought to have been caused by the distraction of drivers. National Motor Vehicle Crash Causation Survey has collected on-scene information about the factors leading up to crashes on a sample of 5470 crashes and results showed that 94% TA are caused by drivers and most frequently assigned critical reason (41%) was recognition error which includes distractions [1]. Among the most dangerous distractors is cell phone manipulation, which can include, among other things, writing a message on a mobile phone while driving. The worst consequences of distracted drivers are serious injuries or death due to the inability to react in a timely manner to a sudden traffic situation. Autonomous vehicles can reduce the negative impact of distraction, but at the same time there is a risk that as the level of automation increases, the physical and mental load will decrease. There is a risk of too much relief where the driver will engage in secondary distraction tasks that can prolong his reaction time in critical situations when the system will require the driver to take commands. This problem will be present until reliable advanced driver assistance systems (ADAS) to correct the errors in the performance of driver, are designed. Short literature review took place to analyses and prove the hypothesis of how cabin distraction can negatively affect the performance of road vehicle drivers. Methods used to conduct this research are a compilation and comparison of available knowledge from scientific and professional papers mostly found on Google Scholar.

2. THE IMPACT OF DISTRACTION ON DRIVER PERFORMANCE

There is no unambiguous definition of distraction. Driver distraction can be explained, according to Dewar et al. (2007), as the instantaneous "diversion" of attention from the primary task of driving a vehicle to a thought, object, action, event, or person. A person whose cognitive process is disrupted is always more susceptible to a slower reaction than a person who is fully focused on driving and aware of their surroundings [2].

Overall, two main approaches define distraction in driving [3 - 5]. The first approach defines distraction as present when attention directs away from goals important for driving. That makes driver behavior risky concerning safe driving. This approach allows drivers to divert attention from the drive as long it is secure. Therefore, to detect a distraction, the goal would be to define a good enough performance. In the second approach, attention is distracted from driving when the results are: delayed response, increased workload, and sometimes changes in speed and maintaining vehicle position on the road. This approach defines distraction as a change of attention to everything else that is not important for driving, regardless of the outcome. The claim does not allow attention to shift from driving and requires setting a fixed threshold. Therefore, any activity that takes attention from the driver is considered a distraction. In addition, to detect a distraction, one would first have to define optimal performance. However, drivers can and do adapt their behavior to the task requirements. Furthermore, drivers can perform additional tasks without distraction. In addition, they utilize the available attention capacity to engage in secondary activities (using mobile phones or consuming food). Research shows that engaging in additional tasks does not always increase the likelihood of a collision [6] and often depends on the level of mental load. Most devices measure distraction when the driver looks in a different direction from the road for a certain period (continuously or consecutively). However, attention is more than where a person directs his gaze at a particular moment. The driver must have a working mental representation of the situation, a plan of where to gather the necessary information, and what to do next. Therefore, the driver is attentive when he fulfils the minimum criteria for every traffic situation. Kircher and Ahlstrom (2016) describe it as a minimum required attention [3]. Different aspects need determining to measure the minimal information for a particular performance. These are prototype situations and traffic relevant goals, minimum requirements for the gaze direction, and a sampling of information (driver behavior concerning minimum requirements). There are various methods for the assessment of the level of mental load. The first method is eye occlusion. This method allows the estimation of available reserve visual capacity [7]. The second method is expert knowledge based on rules on where the driver should focus. For example, extensive overview of the environment, the eyes need to move, the driver needs to scan the entire traffic environment, look in the mirrors and instruments, focus gaze for a certain amount of time on a specific goal [8]. Most often, an eye-tracker monitors the driver's vision direction. This method allows measurement of saccades or changes between gaze direction and fixations or direction, duration, frequency of view for a specific gaze. The third method is driver self-assessments. This method allows insight into the capacity of the working memory of drivers [9]. The theory of Minimum Required Attention [3] has some advantages and some disadvantages. On the one hand, it provides a framework for different distractions such as visual, cognitive, sound, and manual. On the other hand, it requires a demanding process of defining all criteria for operationalization and an extensive database of defined traffic situations. Furthermore, how often information needs to be collected to ensure mental representation depends on proximity and speed relative to other vehicles, traffic restrictions, infrastructure, and traffic activities.

A growing number of drivers perform several actions at the same time while driving (e.g., using smartphones, eating, and drinking, smoking, talking to a passenger, etc.), which can negatively affect the driver's performance and thus to the occurrence of TA with severe consequences and / or death. According to Ray Fuller, distraction causes a slower response to stimuli from the environment because the driver's attention is divided into two tasks (so-called divided attention), the task of driving a vehicle and the secondary task of distraction [10]. Distraction is divided into three main groups [2]: visual distraction; manual (biomechanical) distraction and cognitive distraction. Reading, writing, and sending a text message on a mobile phone held by the driver in a dominant hand while driving a motor vehicle is an example of simultaneous visual, cognitive, and biomechanical distraction. Degrading performance is equally detrimental to talking on a cell phone if the driver does not hold it with his dominant hand [11]. In the last few years, in the field of research on the distraction of drivers of road vehicles, the assessment of the driver's field of vision has been a popular topic because the direction of the driver's gaze is considered an important characteristic of driver behavior and attention to the task of driving [12].

Considering amateurs and experienced drivers, amateurs most often make eye movements without moving their head, while experienced drivers move their head and eyes at the same time [13]. An example of a very frequent process of divided attention during the operation of a car is a conversation on a mobile phone, which in addition to a very dangerous cognitive distraction is an example of simultaneous manual distraction (if the driver holds the mobile device with the dominant hand). Devastating statistics on TA in the USA indicate that every 4th car accident is caused by the distraction of sending a message on a mobile phone while driving and that sending a message on a mobile phone while driving has a six times higher risk of a car accident than driving under the influence of alcohol [14]. Several studies show that drivers do not usually extend the duration of a single glance of more difficult or longer tasks, but increase the frequency i.e., the number of glances from the road [15]. Victor et. al. investigated how secondary tasks i.e., distraction within the vehicle (cabin distraction) affect the driver's eye movement [16]. The more complicated secondary task i.e., distraction inside the vehicle became (increase in stimuli), the driver's view was less focused on the road ahead and more on the screen in the vehicle. According to [17], drivers are more susceptible to interference from inside the vehicle (radio, climate adjustment, navigation, etc.) than those from outside, which means that there are two basic categories for visual attention: external distraction i.e., distraction factors from road scenarios (traffic environment) and internal distraction i.e., distraction factors from the vehicle steering wheel. A 2006 report on the results of a naturalistic study involving 100 cars came to the results is that almost 80% of all crashes and 65% of all traffic situations that nearly resulted in a crash involved drivers looking away from the road just before the incident [18]. Engaging in visually distracting activities distracts drivers from the road and causes degradation of performance, such as: imprecise vehicle control, increasing reaction time [19] and driver errors [20].

Cognitive distraction is a critical area of distraction, especially in relation to listening and talking tasks, but also to the spontaneous appearance of processes such as daydreaming or the appearance of the so-called state of "lost in thought", which can often occur on long monotonous rides [21]. Tasks that impose a cognitive workload on the driver result in two unique indicators of cognitive loads [16, 22]: high percent road centre of gaze; unusually long glances toward road centre. Actions such as writing a message on a mobile phone and consuming food and drink while driving fall into the category of manual distractors that are increasingly present in the modern world. For this reason, to date, many studies have been carried out to measure the impact of manual distraction on the performance of road vehicle drivers both in real terms and under simulated conditions. The negative impact of writing a message on a mobile phone while driving and talking on a mobile phone was most often examined, where the study [23] noted a reduced percentage of views in the main zone "Left part of the windshield" while reducing the number of zones used compared to baseline driving. There are also studies on the impact of eating food and drink while driving, and the impact of multiple actions sequentially performed (writing a message on a mobile phone and consuming food/drink). A study conducted in 2015 [24] to analyses the impact of texting on a mobile phone, food, and beverage consumption on the performance of road vehicle drivers under simulated conditions by measuring the reaction time of the driver and the standard deviation of the position of the vehicle in the lane showed interesting results. Drivers affected by the distraction of texting on their mobile phone find it more difficult to maintain the position of the vehicle in the lane compared to baseline driving, also affected by food consumption distraction. Reaction to sound stimuli influenced by the distraction of writing a message on a mobile phone in relation to baseline driving is slower (922 ± 95 ms vs 889 ± 104 ms, p=0.007), also influenced by food consumption distraction (933 ± 101 ms vs 889 ± 104, p=0.04. In a situation of manual distraction of beverage consumption compared to baseline driving, there is no difference in the performance of the driver. By subjective assessment, most respondents said that writing a message on a mobile phone while driving is the most difficult task of the three mentioned [24]. The 2012 study [25] looked at the impact of mobile device use under different conditions (informal hands-free conversation, cognitively demanding hands-free conversation, and cell phone message writing), and the impact of different levels of alcohol intoxication (from 0.00 to 1.00 ‰) on the performance of road vehicle drivers in the simulator.

The results of the study [25] showed that in relation to baseline driving (relaxed driving in the comfort zone), it took longer for drivers to brake when they were affected by distraction, spent less time at a defined speed interval, and took longer to accelerate the vehicle. In multitasking, the driver's workload increases and exceeds the limits of their capability, which is why mostly experienced drivers aim to reduce the negative impact of cognitive distraction by the following measures [26]: reducing the speed of the vehicle and increase the distance between two vehicles.

Kircher et. al. (2009) [27] investigated that under cognitive distraction, the percentage of time a driver spent observing the road ahead was more than 92% in a field study. Therefore, eye and blink detection and measurement measures can be used to detect cognitive distraction. For example, He et al. [28] observed that "mind wandering" affects patterns of view and blink rate like those observed during periods of cognitive secondary task. The negative impact of distraction can be reduced by introducing ADAS, but there is a danger of involving the driver in secondary distraction tasks due to excess free mental load.

3. THE IMPACT OF AUTOMATED DRIVING ON DRIVER PERFORMANCE

In January 2014, SAE defined a common taxonomy and definitions for six levels, where level zero implies vehicles without any automation, to the last, fifth level, which implies full automation for cars known as the colloquial name autonomous vehicle [29]. With the increase in the level of automation of vehicles, there is a possibility of greater relief of drivers from cognitive-motor tasks. However, there is a danger that drivers will relax too much, and that they will stop observing the environment and other vehicles on the road, which will allow them to further engage in secondary distraction tasks.

In scientific studies of the impact of automated driving on driver performance, the results are interesting. In the work of Morando et al. (2019) the aim was to analyses driver behavior during manual and second level automated driving (L2) [30].

The impact of automated driving showed a statistically significant decrease in the parameters of the percent road centre compared to manual driving, which is interpreted as a decrease in the difficulty of the task of driving when using vehicle automation. In another study [31], scientists investigated the impact of distraction on L2 compared to manual driving through the driver's gaze duration parameters on and off the road. Based on the results, the range of off-road gaze duration was significantly influenced by driver distraction tasks in manual and automated driving.

The results of the data analysis showed that this impact is more pronounced for longer off-road glances. Furthermore, long off-road glances for different tasks are a potential indicator of different levels of driver distraction. A greater increase in long off-road glances occurred in tasks characterized by a greater number of necessary steps to perform the same. In automated driving, distraction tasks increased the duration of off-road glances before taking commands but did not increase reaction times. In a naturalistic study, Gaspar and Carney (2019) explored how drivers focus visual attention during L2 [32].

On average, drivers looked ahead 74% of the time, 13% on the dashboard and steering wheel, and only 3% on the touchscreen. Driving with the autopilot on affected the duration of the glances by having drivers redirecting glances of longer duration (928.19 ms) compared to when the autopilot was turned off (746.60 ms). Area of interest was also a statistical predictor of average glance duration, with an average longer glance duration on the touchscreen (954.45 ms) than on the dashboard (776.15 ms). In another study, the focus was on investigating driver behavior during the L2 compared to when such a system was switched off but at the same time available to drivers [33].

The results of this study suggest that drivers spend more time looking off the road during L2 engaged and that drivers are more likely to perform actions such as browsing the internet. Also, the inclusion of drivers in high-risk secondary tasks was higher with the system on compared to when the system was available but was not used. On the other hand, the results of the Solís-Marcos et al. (2018) have shown that in relation to previous beliefs, drivers have not paid more visual attention to the secondary task of distraction during the vehicle automation engaged [34].

Most of the available research has focused on another level of automation because it is currently widely available in the commercial market, while the effect of higher levels of automation is currently unknown. The authors believe that increasing the level of automation will negatively affect driver engagement in secondary distraction tasks and in this way potentially such vehicles will be exploited beyond the limits and capabilities of such a system.

4. DISCUSSION AND CONCLUSION

In this paper by compiling and comparing knowledge from scientific and professional literature, the hypothesis of how the distraction factor can negatively affect the performance of road vehicle drivers has been proven. The results of the research mentioned in this paper explicitly point to the negative consequences of the influence of the same by reducing the reaction time of drivers to environmental stimuli and reducing the level of driver performance in relation to when drivers are not affected by, which can result in traffic accident if a higher level of automation or ADAS in the car does not prevent it, or "lacky escape" does not occur.. By studying the behavior of the driver and analyzing the patterns of eye movement, we can conclude that the negative consequence of distraction is diversion of attention from the task of driving the vehicle to secondary distraction tasks. If the driver spends more time running two tasks in parallel and in doing so does not refresh his memory with new information coming from the environment, at critical moments, when the vehicle's trajectories intersect, drivers are unable to react in a timely manner and avoid an undesirable outcome.

To prevent the occurrence of TA, it is necessary to increase the awareness of stakeholders of the transport process about possible negative consequences through education. Also, continuously invest in ADAS that will connect the transport environment, driver and means of transport in real time. It is also necessary to invest in transport infrastructure; and it is necessary to actively regulate the speed of traffic.

This paper was written with the goal of gathering existing basic and advanced knowledge (state of the art) and consequently developing a scenario for measuring driver performance on a road traffic simulator, which is the next step in the project. Future research will focus on developing a framework for assessing driver behavior under the influence of different distractive conditions, with an emphasis on the combined effect of concurrent multiple types of distractions due to insufficient data available in the literature.

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Degradarea performanței conducătorilor de vehicule rutiere din cauza influenței distragerii atenției cabinei

Rezumat: Efectuarea simultană a mai multor sarcini poate avea un impact negativ asupra performanței șoferului, inclusiv asupra apariției accidentelor rutiere (AT). Se va investiga posibila influență negativă a factorului de distragere a atenției asupra performanței conducătorilor de vehicule rutiere. Cel mai periculos este scrierea mesajelor text pe un telefon mobil în timp ce conduceți. De asemenea, efectul utilizării unui telefon mobil în timp ce conduceți pe performanța unui șofer este același, indiferent dacă șoferul deține un telefon mobil cu mâna în timpul unei conversații sau nu. Creșterea gradului de conștientizare cu privire la consecințele negative ale distragerii atenției și dezvoltarea unui sistem avansat de vehicule este necesară pentru a reduce proporția tot mai mare a acestor accidente.

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