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Road and Rail Infrastructure III

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RECORDING AND EVALUATION PROCEDURE OF DRIVERS' DISTRACTION IN ACCORDANCE WITH DRIVER'S CHARACTERISTICS IN HIGH SPEED ARTERIALS

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Abstract

Over the last years, distracted driving constitutes a considerably increasing road safety problem with disastrous results and it possesses a leading position among the accidents causes. The present study deals with driver's distraction due to out of the vehicle factors as well as factors related to the driver such as age, gender, driving experience etc. Considering exterior factors as the most significant, we can group them in four categories: built roadway, situational entities, the natural environment, and the built environment. Regarding the fourth category, it is related to the wide variety of civil infrastructure, the commercial land use combined with the high vehicle speeds. All these contribute to the setup of a very dangerous environment by increasing driver's distraction and inattention. This research is based on a medium scale experimental procedure which took place in three urban freeways in Greece, using a sample of 77 drivers. The distraction of the driver's attention is evaluated via a continuous recording of his gaze which acts as the main indicator regarding driver's performance. The main objective of this paper is to assess the side effects of roadside advertising and overloaded informational signs to driver's distraction and inattention. The results of this type of research procedures are very useful as a tool to prevent the forthcoming pressure for more and more billboards and trademarks on the roads as well as to encourage the adaptation of more precise regulations with regard to the road infrastructure, the placement of roadside elements, etc.

Keywords: Driving, distraction, advertising, billboards, naturalistic, research

1 Introduction

Distracted driving is a growing road safety problem and also the leading cause of car accidents. The nature and the specific characteristics of distraction have not yet totally clarified but the most of the route has already been covered as many researchers try to obtain all the necessary information to manage this phenomenon. The most crucial information, though, is about the nature of distraction and the dilemma whether or not distraction is differentiated from inattention. According to Regan et al. (2010) the taxonomy of inattention includes five major categories: Driver Restricted Attention (DRA), Driver Misprioritised Attention (DMPA), Driver Neglected Attention (DNA), Driver Cursory Attention (DCA), Driver Diverted Attention (DDA). Driver distraction as it is defined in this research is the last category of Regan's taxonomy.

2 Basic characteristics of distraction

The first step to a proper approach is to understand the basic characteristics of distraction as it appears in general. Many researchers have tried to define driver distraction and as a result the related literature contains a significant number of those definitions. In the first International

Conference on Distracted Driving (Hedlund et al. 2005:2) the scientific community agreed on a definition for distracted driving: "Distraction involves a diversion of attention from driving because the driver is temporarily focusing on an object, person, task, or event not related to driving, which reduces the driver's awareness, decision-making, and/or performance, leading to an increased risk of corrective actions, near-crashes, or crashes".
Distraction may be visual, cognitive, biomechanical and auditory (Ranney et al. 2001). Distraction at all forms, has become object of research recently, with distraction from a secondary task concentrating most of the research on the subject, particularly after the widespread use of mobile phones and the integration of driver assistance systems in modern vehicles. Naturally, priority is given to drivers of passenger cars without overlooking the other road users' categories such as truck drivers, motorcyclists, bicyclists etc (Misokefalou et al. 2010).
The main causes of distraction are classified into two categories: Those coming from the interior of the vehicle and those from the external environment. In the second category, one finds some very important potential sources of driver distraction which can be grouped in four major categories: built roadway, situational entities, the natural environment, and the built environment (Horberry et al. 2009). According to Horberry et al. one component of built environment which consists the fourth category of the previous categorization is the billboards and any other kind of road advertising. In the case of causes related to advertising, it should be particularly emphasized that the purpose of their presence at some point at the roadside, or even in a moving vehicle in the road, is to capture the driver's gaze in order for him/her to devote the required time so as to assimilate the information obtained. Roadside advertising billboards are designed by their very nature to attract attention. Crucially, though, the related potential threat to road safety is generally not acknowledged by the industry (Crundall et al. 2006). This is the reason why distraction by advertising is a very significant road safety phenomenon which must be elucidated by using all the available means and methods.

3 Frequency of driver distraction in crashes

The importance of this issue emerges from data which shows distraction from a secondary task as a cause of serious accidents as well as crashes. Particularly for billboards, Crundall in his study (Crundall et al. 2006) supports that though it is acknowledged that research into advertisement distraction has been extremely limited (Beijer et al. 2004), the few studies that have been conducted have demonstrated that drivers do look at and process roadside advertisements (Hughes et al. 1986), and that fixations upon advertisements can be made at short headways or in other unsafe circumstances (Smiley et al. 2004). Previous studies of accident statistics have also identified external distractors, including advertisements, as a significant self-reported cause of traffic accidents (Stutts et al. 2001). Particularly, for roadside distractors, evidence is mounting that roadside distractions (and advertising in particular) present a 'small but significant' risk to driving safety (Lay 2004). Conservative estimates collated from a review of several accident databases put external distractors responsible for up to 10% of all accidents (Wallace 2003). This is confirmed also by a recent simulator study (Young et al. 2009) in which there is a tentative suggestion that more crashes occur when billboards are present.

4 Method

4.1 Methods of evaluating driver distraction

The use of standardized methods gives the researchers the possibility to exchange data, conclusions and best practices. Therefore, it is important to detect the most suitable method of data collection (Rockwell. 1998). This aim can be achieved through a comparative study between the allocated methods, examining the advantages and disadvantages of every method separately as well as the usefulness and necessity of the results that every one of

them produces as the only certain way for the researcher to detect driver's distraction is via the results that distraction produces. An analysis of this kind was made by the Univerity of the Thessaly (Eliou et al. 2009). During this study all the available methods were examined. The most popular among the available methods are based on elements of accidents, on experiments, on observation and surveys. Furthermore, there are some methods that are not included in any of the previous categories like Peripheral Detection Task and Visual Occlusion.

4.2 Selection of the appropriate method

The method considered the most appropriate is an observational-naturalistic study, which takes place in the field, using specially equipped vehicle to record the driver's eye movements and measure the frequency and the duration of the glances at every object considered potential source of visual distraction. The available equipment (Facelab machine) is capable of making continuous data recording. The main advantage is that with this method, in contrast with all the others categories, driving comes as close to the real thing as possible which is important for the research when we study human reactions. Naturally, there are some limitations both in designing and carrying out the experiment. The most important of these is the limited number of participants in comparison with other methods like questionnaires study, the unfamiliar vehicle which causes stress to the driver, the anxiety because of the sense of being monitored as the vehicle is equipped with cameras and, finally, the subjective discretion of the analyst-observer at the data processing.
Captiv software, which is compatible with FaceLab L2100, was used for the analysis of the results. This software gives the opportunity to analyse the data in detail by recording the number of glances at every billboard as well as the total time that the billboard captured driver's gaze during driving. At this point it should be noted that as distraction, in this study, is considered the continuous or intermittent but repeated capture of the gaze from a theme for longer than a total of two seconds as glances that last more than this time are related to driving errors (Rockwell, 1998). Smaller time intervals (0-0.7 seconds, 0.7-1.0 seconds, 1.0-1,6 seconds, 1,6-2.0 seconds ›2 seconds) were also studied in order the results to be comparable with the results of other related studies. Highly experienced analysers carefully analysed the produced by Facelab machine videos and all the data were statistically analysed.

5 Experimental site

The research took place from June 2011 to February 20102, in 3 suburban roads in Greece. The first road is Attiki Odos, a freeway in the city of Athens. There were three routes under observation with a length of 19, 16.8 and 15 km respectively. The second road is Leoforos Kifisou , an arterial road in the city of Athens and the route under observation has a total length of 10 km. The third road is the national road between the city of Thessaloniki and the city of Giannitsa. The studied section is 7.7 km. In the last two roads, drivers drove both directions. The flow of vehicles is continual without being interrupted by traffic lights. The speed limit of the road is 90km/h. The total number of the points at which the data were collected is 136, of which the first 69 are at the first route, the following 40 at the second route and the last 27 at the third route. In this study other objects besides the advertisement has been selected to participate in order to act as comparison points to the advertising.

6 Participants

Using volunteer drivers, who are required to drive a car on the three selected roads, under the supervision of the researcher, who was always in the passenger seat checking the proper function of the system, the obtained results are characterized by a high degree of reliability and validity. Seventy seven drivers participated in the surveyof which 62% are men and 38% women.

The drivers were selected with criterion their familiarity with the selected roads in order to eliminate the stress which an unfamiliar route induces. All drivers were familiar with the road, as they use it in a daily basis, but the subject of the study was completely unknown to them. Regarding the limitation of the unfamiliar vehicle, each one of them, in order to become familiar the vehicle drove the selected route 2 times before the third run which was the one that we focused our attention at during the analysis process. The drivers are between 26 and 45 years old and the vast majority of them, in all three traffic routes, possesses a driving license and drives systematically for more than ten years.

7 Material - Data collection

The equipment used in the survey was very carefully chosen in order to produce the optimal quality, completeness and integrity of results. It includes a passenger vehicle and a monitoring and recording system (Facelab, Seeing machines), which detects and records every single movement of the driver's gaze and the driver's head. It is composed of two cameras for the recording of the above and an external camera for the recording of the road scene. All measurements for the experiment took place during the day, under normal traffic conditions as well as normal weather and lighting conditions.

8 Results

In this study, the information isolated and analysed in depth, is related to the external impulses that cause driver distraction and concentrates interest mainly on billboards near the road and their role in driver's distraction of attention. For this purpose, many sites of interest related to advertising along the road were identified and mapped for routes of every road. Among them there are billboards, banners, soundpannels with graffiti and posters on them and gas station signs. Additionally, other elements on the road, such as road signs and buildings were parts of the study. The analysis included an examination of driver behaviour, as far as concern the reactions of drivers' pupils of the eyes while driving under the existence of these potentially evocative distraction elements of the road environment.
The following 3 figures (Fig. 1,2 and 3) show the results from the analysis of the gaze direction to the observed points of each route. Each driver drove the selected route 3 times but we decided to focus our attention at the third one because of the familiarization of the driver with the vehicle which was analysed at the method section. As it shows, there are certain points on the route which attract attention more than the allowed, from the aspect of safety, time.
The detailed analysis of the data came from the eye gaze, in terms of glance duration, led us to the conclusion that the selected points could, in their majority, characterized as attractors with an intense role in the driver visual field. Furthermore, from the four major categories under research, the one that seems to capture driver's eye the most is billboards. Furthermore, there are many of them that attract the gaze for more than 1,6 seconds, a time interval that according to Lee (2007) is dangerous for the safe implementation of the driving task. The time frame of the 1 second that many researcher like Zwalen (1988), Rockwell (1998) and Wickman (1998) characterize as the safe limit, is being surpassed at most of the points. If we decide to adapt Beijer's (2004) opinion about safe eye behaviour, according to which glances for more than 0,7 seconds away from the driving task could be unsafe for the execution of it, all points with minor exceptions could be considered as possible risk points.
The multiple regression examined if the 24 variables under research (age, gender, driving experience, number of point, category, number of lines at the point, direction of the point, object into a tunnel, position of segmentation, distance from the road, luminosity, number of objects at the point, median barrier, position, size, emergency lane, road category, time, weather conditions, distance from the start, distance from the leading vehicle, traffic volume, speed, number of glances) can predict drivers' total distraction time.

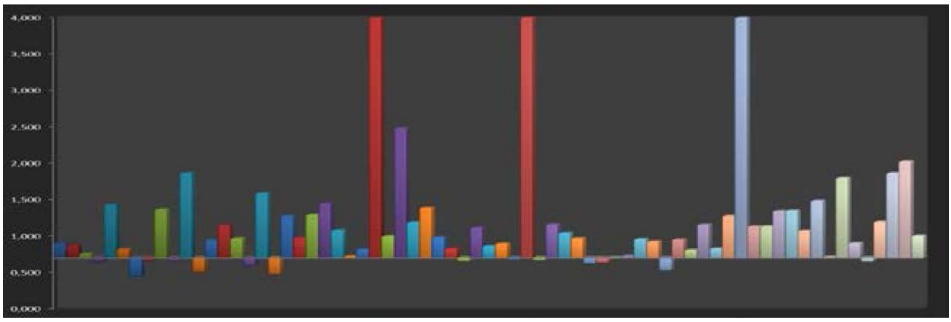

Figure 1 Mean of the time interval dedicated to each point at Attiki Odos road

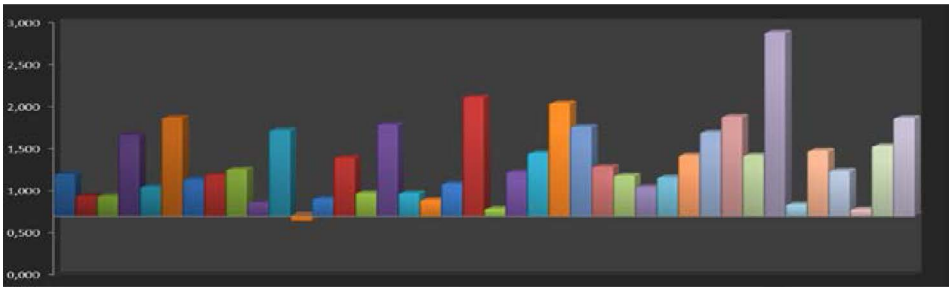

Figure 2 Mean of the time interval dedicated to each point at Leoforos Kifisou road

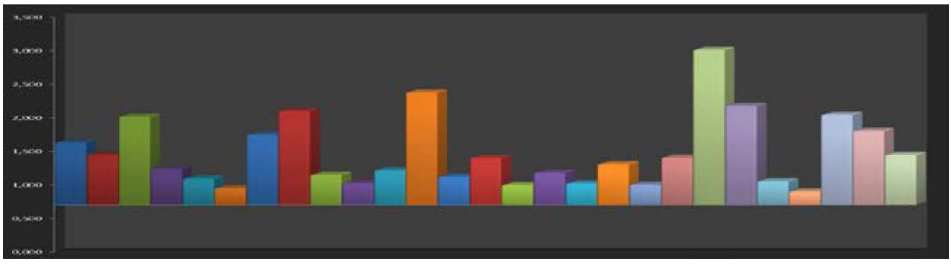

Figure 3 of the time interval dedicated to each point at Thessaloniki – Giannitsa road

The multiple regression produced a weak fit with the data ($R^2 = 0.038$ & adjusted $R^2 = 0.030$) most probably due to the number of variables in the model and thus in the equation. Still, the combined influence of the variables was an excellent predictor of the total time producing a statistically significant result ($F(24, 2840) = 4.658$, $p<0.01$). Specifically, the statistically significant variables are the following:

Significantly positive relationships were identified between the number of the points: $t(2840) = 3.736$ with $p<0.01$ (as the number of the point increases by one unit, the total distraction time will increase by 0.007 seconds), the size of the object: $t(2840) = 2.111$ with $p=0.035<\alpha=0.05$ (as the size of the point increases by one unit, the total distraction time will increase by 0.153 seconds) and the number of the glances: $t(2840) = 4.450$ with $p<0.01$ (as the number of glances increase by one unit, the total distraction time will increase by 0.15 seconds).

Significantly negative relationships were identified between the distance between the point and the road: $t(2840) = -3.718$ with $p<0.01$ (as the distance from the road decreases by one unit, the total distraction time will increase by 0.319 seconds).

Thus, the regression equation for the statistically significant results is the following:

$$\begin{aligned} y &= a + b\times 1 + b\times 2 + b\times 3 + b\times 4 \\ &= 0.085 + 0.007 \times \text{no of point} - 0.319\times \text{distance} + \\ &\quad + 0.153\times \text{size} + 0.15\times \text{no of glances} \end{aligned} \tag{1}$$

The variables that gave statistically significant results at the regression are being further examined in order to conclude about their influence on the total distraction time.

9 Conclusion

Distraction of driver's attention during driving is a major road safety problem, which threatens not only the driver's safety but also the safety of other drivers and road users. The focus of the research on drivers of passenger vehicles is due to the fact that those drivers consist the largest category of road users with growing involvement in accidents, which are caused by the distraction of driver's attention. The goal of the research is to identify and clarify the causes, the frequency of appearance and the way that certain factors influence the distraction of attention of each driver, focusing on the role played by roadside advertising in Greece as a parameter of the distraction of the driver's attention.

The methods commonly used in a study of driver distraction aren't all feasible or effective to the same extent. The chosen method allows the continuous data recording with its main advantage being the fact that driving is as close to the real thing as possible. Thus, the results are characterized by a high degree of reliability and validity. It, also, gives the opportunity to the participant to have an adjustment period with the vehicle in order to obtain a normal driving behaviour. The small possibility of the researcher to control the situations and create desirable driving scenarios is among the disadvantages of this method. The environmental conditions, also, cannot be controlled. Another disadvantage is the increased cost of the method due to the eye tracker. Finally, as disadvantage of the eye tracker we could mention the difficulty of the installation in the car as well as its sensitivity to changes (e.g. lightness conditions).

This research concluded that all roadside billboards of the route and many other objects which belong to the categories "road signs" and "built environment" distract driver's attention in a degree which could be considered as dangerous. Among the road characteristics, the driver's characteristics, the characteristics of the point and the conditions of the measurement there are some variables that are statistically significant regarding the distraction of the driver's attention. More specific, the statistically significant variables are the number of the point, the size of the object, the number of glances at the point and the distance between the point and the road.

Much of the data analysis requires collaboration with experts such as psychologists and doctors in order to provide an integrated approach. Furthermore, a comprehensive policy to reduce the visual pollution near the roads, such as billboards, can help not only to improve the road aesthetic but also to significantly improve road safety by eliminating driver's visual distraction of attention. The results of this type of research procedures are very useful as a tool to prevent the forthcoming pressure for more and more billboards and trademarks on the roads as well as to encourage the adaptation of more precise regulations with regard to the road infrastructure, the placement of roadside elements, etc.

To sum up, it is a fact that driver distraction is a major cause of accidents; therefore, the responsibility over the issue translates into efforts to reduce the number of injured and dead drivers. In order to achieve that, the solution of the distraction phenomenon could be found in the combination: "research-education-design- legislation".

This research is under further analysis, as a number of 24 variables - from the road, the conditions, the points and the driver - is available to the researchers and is being further statistically analysed in order to conclude about the contribution of the selected variables in driver distraction.

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