Driver Distraction of Cyclists in Urban Environment: A Methodological Approach

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Abstract: Undoubtedly, road accidents are a public health problem, the impact and importance of which have increased in recent decades. Road safety data have systematically shown how cyclists are very vulnerable to being involved in a car accident and suffering serious injuries resulting from it. Furthermore, although the data are still very limited, in addition to the other human factors involved in cycling accidents, distraction when using the bicycle seems to contribute significantly to the road risk of riders. It is well known that driving is a complex process that requires the simultaneous existence of physical, mental and sensory abilities. Despite the complexity of driving, it is observed that drivers deal with things that are irrelevant to the driving task. And this is a huge problem in transport safety, the distraction of the driver. With the growing number of portable devices as well as the electronic help and entertainment systems offered to the driver, the sources of distraction are constantly increasing. The purpose of this study is to understand the phenomenon of driver distraction and to export results, important for the progress in dealing with the phenomenon by the various agencies that can be used as a basis for further research. More specifically, a summary of the recent literature on driver distraction is made, focusing specifically on the distraction of drivers, both by technological means and by external factors. Finally, a methodological approach is applied to the phenomenon, and in particular to the distraction of the bicycle driver in the urban environment, which includes the realization of an experiment in real conditions in the city of Volos. The research involved 15 drivers, who were asked to perform a specific route by cycling and following specific instructions through a navigator. The data collected were analyzed and showed that the phenomenon of driver distraction is real and is a high-risk factor.

Key words: road safety, cyclists, driver distraction, distraction sources, navigation

1. Introduction

Given the great importance of urban mobility and transportation as key parts of people’s daily lives, road safety is an essential element of social well-being. At the same time, road accidents pose a very serious threat to public health as more than 1.3 million people worldwide die each year as a result of road accidents, making road accident injuries the leading cause of death worldwide. In this regard, transportation dynamics are constantly changing, and different alternative modes of transportation are forcing us to reconsider the role of road safety as a mainly vehicle/infrastructure-related issue, increasing our awareness of accident causes and related intervention with the goal of preventing negative safety outcomes for road users, based on human factors research [1-3]. However, most of the available transport safety research was based on motor vehicles and their users, without considering that many factors affecting road safety also depend on those who choose to use alternative means of transport such as bicycles.

Road accidents involving cyclists, especially in recent years, have raised concerns among public health organizations and road safety officials. Given the complexity of cycling work and the
often-problematic interactions of bicycles with heavier vehicles, with other road users, but also with road infrastructure, one of the factors necessary for the well-being of cyclists is to maintain their attention focused during their travels, on the driving work they have to perform, thus dealing with the unforeseen dangers and demonstrating the safe driving behaviors required by the use of the bicycle. In other words, cyclists’ attention should not be distracted while riding.

This study was conducted in a need to approach the effect of driver distraction on bicycle riders. In order to achieve this, an experiment was conducted at a specific route in the city of Volos, Greece. In this field test, a group of fifteen volunteer bike riders were asked to follow a route while receiving auditory and optical instructions from a navigating application. Collected data were analyzed. The results of the experiment performed, showed that the phenomenon of driver distraction is real and is an important factor in causing road accidents in urban environments. Bicycle riders distracted their attention away from the road many times and for multiple seconds. Findings also showed that participants who are also bicycle users, turned their eyes away from driving-related activities for a longer period, compared to those who do not use a bicycle. In contrast, riders who were less familiar with navigating were observed to have shorter distraction times.

2. Literature Review

Studies on the effects of distraction while driving have used various definitions. It is also common not to translate the term of driver distraction accurately. This has to do with the nature of the word distraction. The meaning of the word is relatively vague, without having the necessary precision needed for its scientific analysis. The word distraction in the dictionary is defined as “the distraction of the mind, attention, etc. from a particular object — the fact where one’s concentration or attention is disturbed by something”.

We therefore understand that the general meaning of the word cannot include the complexity of the concept of “distraction” when referring to driving.

As pointed out by Pettitt et al. (2005) [4], there is great diversity among surveys regarding the term “driver distraction” and many of them are done without first defining the structure of the term. According to them, the concept of driver distraction is an everyday term that tends towards something abstract and is not precise enough to be used for scientific purposes. So, this diversity in the definition can become problematic. Nevertheless, it is understandable that different definitions come from different purposes. Many definitions focus on the structure of attention, as well as its distribution, describing the process by which distractions affect drivers. Distraction is related to the process of distribution of attention. Also, several definitions take into account the outcome, such as how much it affects the reaction time, the position on the road, the risk of an accident or driving safety. Defining distraction only with specific results is problematic, because the existence of distraction or not will depend on a random selection of combinations of road events. Various definitions of driver distraction that have been formulated are:

• Shifting attention away from stimuli critical to safe driving to other non-driving ones [5].
• Occurs when any activity distracts the driver from the driving activity [6].
• Driver distraction involves objects or events, both inside and outside the vehicle, that are used to divert attention away from the driving task or to capture the driver’s attention, leaving not enough resources to perform correct driving [7].
• Driver distraction can be defined as a misallocation of attention [8].
• It is any activity or process that adversely affects a driver’s ability to process information related to safe driving [9].
The following definitions were used to characterize driver distraction based on the failure of human functions as factors that have a role in road accidents:

- Driver distraction occurs: “whenever a driver delays in recognizing the necessary information needed to carry out his driving task safely, because an event, an activity, an object or a person, inside or outside his vehicle has forced or tended to cause the driver to be distracted from driving task” [10].

- Driver distraction results “from interference between a driving task and an external stimulation without link with driving (e.g., guide a vehicle and tune the radio). This secondary task can be gestural or visuo-cognitive” [11].

- “Driver distraction is a diversion of attention away from activities critical for safe driving toward a competing activity” [12].

It is therefore observed that some definitions describe distraction in terms of its effect on driving performance, others describe it in terms of activities or objects that lead to distraction, and most describe it as something that disrupts the driving task. An approach to formulating a well-established definition of driver distraction was made at the 1st international Conference of Distracted Driving, which took place in Canada in 2005, and defines it as: “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 ability and/or performance, leading to an increased risk of corrective actions, near-crashes, or crashes” according to research by Hedlund et al. (2005) [13].

At a time when multimedia technology systems and driver-assistance systems are becoming increasingly ubiquitous, the likelihood of additional form of driver distraction appearing is considerable. Interacting with all these services is now considered part of the driving procedure. Driver distraction can be caused by a variety of modern technology, including cell phones, heads-up displays, smartwatches, and smartglasses, as well as the navigation systems investigated in this study.

Navigator is now one of the most popular driver aid systems on the market. The goal is to give the driver all the information about a route that is available. As a result, it might be deemed highly effective in terms of improving driver performance, particularly on roads he is unfamiliar with. Furthermore, most navigation systems include dynamic route assistance, which selects the optimum path for the driver (e.g., avoiding high-traffic roads). Drivers must first enter their destination, after which the system will display the shortest route to that location. The system will then show them turn-by-turn directions and directions on how to get to that destination. In terms of human-driver interaction, navigation systems come in a variety of forms. Some are pre-installed in the vehicle (typically from the manufacturer) and consist of a screen that is placed in the centre of the dashboard. Other devices are frequently mounted to the windshield as separate devices. Smartphones, which come with a variety of navigation apps, are also popular.

Knapper et al. (2015) [14] used in-vehicle naturalistic driving to examine the usability of portable navigation systems in ordinary automobile driving. Seven female and fourteen male experienced users of navigation systems were supplied with a specially geared car for a month. Four cameras, GPS data, and other sensor data were used to document their journey. Participants spent roughly 5% of their journey time dealing with the navigation system, and there was a modest increase in incidences of speeding and they drove at slightly faster speeds when the navigation system was enabled. They came to the conclusion that the findings provided insight into how and when drivers utilize navigation devices. They claim that, while drivers control their use of such technologies to some level, they frequently engage in unsafe behavior while driving. Christoph et al. (2013) [15] performed a
naturalistic driving research on the usage of mobile phones and navigation systems while driving a car. 21 drivers were requested to drive a car for 5 to 6 weeks and operate the vehicle and equipment as they normally would. Four cameras were installed inside the car to monitor the interactions of the drivers. Participants spent 1% of their driving time engaging with the navigation system and 4% of their driving time dealing with their mobile phone, excluding mobile phone talks, according to the findings. In the case of the mobile phone, 48 percent of engagements took more than 15 seconds, while in the case of the navigation system, it was 40 percent. The author came to the conclusion that a significant portion of driving time was spent on secondary activities, which might jeopardize safe driving.

Mora et al. (2012) [16] investigated the effects of manually entering navigator destinations while driving in a simulator. 43 volunteers used the driving simulator SIMUVEG while entering directions into a navigator in order to evaluate the effects on driving performance. The capacity of drivers to maintain longitudinal and lateral vehicle control, as well as awareness of the road scene, was assessed. The results revealed a considerable loss of lateral and longitudinal control, as well as awareness of the visual surroundings, demonstrating the dangers of using electronic devices while driving.

The size and brightness of the GPS display can impact the duration and frequency of a driver’s glances, which can lead to driver distraction. Yared et al. (2020) [17] investigated the impact of the GPS’s display size and lighting level on the performance and safety of young drivers on routes in urban and rural locations in a simulated driving experiment that required the usage of a GPS. According to the findings, driving in an urban environment with a smaller GPS display causes more navigational mistakes than driving with a large one. Furthermore, while using a GPS system to navigate, young, experienced drivers are safer than inexperienced drivers.

Bicyclists’ behavior while using portable electronic devices has been evaluated in three studies. Goldenbeld et al. (2012) [18] showed that adolescent bikers who use portable electronic devices while riding are more likely to be involved in a bicycle accident than their peers who never use portable electronic devices while bicycling. De Waard et al. (2010) [19], investigated bikers in the Dutch city of Groningen, which has a large student population, and discovered that using mobile phones had a detrimental influence on riding performance, especially when texting was included. The effects of listening to music on riding behavior were assessed in a similar research about distracted cycling conducted by de Waard et al. (2011) [20]. Twenty-five people rode their bikes around a track while listening to music through two normal earphones, one earbud, and two in-earbuds. The experiment also featured high-tempo music and high levels of loudness, as well as two mobile phone situations, one in which participants used the phone with their hands and one in which they did not. The authors came to the conclusion that listening to music impairs auditory perception, especially when in-earbuds are employed.

Terzano et al. (2013) [21] investigated riding while conducting secondary tasks in the city of Hague, Netherlands, with an emphasis on using mobile phones, listening to personal audio devices, and chatting with fellow riders. Of the 1360 bicyclists, 47 (3.5%) were using a cell phone, 124 (9.1%) were listening to music on an iPod or other personal music device with headphones, 190 (14%) were engaging in conversation with another bicyclist, seven (0.5%) were smoking, and ten (0.7%) were doing something else not listed on the coding sheet. The completion of a secondary job, which might be a possible distraction, did make a difference in whether the biker acted safely or recklessly. 205 persons (20.8%) of the 984 bikers who were not doing a secondary activity participated in risky behavior. In a study of 376 cyclists executing a secondary activity, 184 persons (48.9%) participated in risky conduct, with a range of 43-51 percent depending
on the task.

The objective of Wolfe et al. (2016) study was to watch bikers in a big metropolitan region in the United States and collect data on distracted riding behaviours that are typical in high bicycle traffic junctions throughout Boston. In this investigation, a total of 1,974 bikers were observed. A total of 615 (31.2%) of the 1,974 were distracted. Auditory distractions were the most prevalent in this investigation, followed by visual/tactile distractions. During the noon commute, the largest percentage of inattentive bikers (40.7%) was recorded (between 13:30 and 15:00). The analyses showed that distracted riding is a common safety risk in Boston, with nearly a third of all bikers engaging in such conduct. All available research done in the last years concerning driver distraction is limited. So is about distraction of cyclists especially on studies conducted under naturalistic driving conditions. In order to bridge these gaps, the current research makes an attempt to approach driver distraction of cyclists by conducting an experiment under real riding conditions while using a navigator.

3. Methods and Data

3.1 Description of Experiment

To approach the phenomenon of driver distraction, a survey was conducted on fifteen bike riders. They were asked to ride a bicycle on a predetermined route within the city while using Eye Tracking Glasses, a device made by SMI. The experiment took place in May 2021 in Volos, Greece. Each of the participating riders followed the same procedure. Wearing eye tracking glasses and receiving instructions from a smartphone navigation application, reached the finish line from start to finish. The drivers did not know the route in advance, so that their reaction times correspond to the real ones.

3.2 Participants

As mentioned above, the participating riders were fifteen in number. A prerequisite for their participation was the knowledge of cycling. Selection of the volunteering riders was made both by the friendly and the family environment. Each of them was asked to fill in a questionnaire after the end of the route, which concerned demographic data as well as data about the use of bicycle and navigator.

3.3 Route Planning

To conduct the research, riders were asked to follow a specific route. This route, with a total length of 900 meters, is located in a parking lot on Spanoudi Street, near the Panthessaliko Stadium of Volos (Fig. 1). A major factor in the area selection process was the safety of the participants. This particular route was suitable due to reduced traffic load compared to others.

![Fig. 1 Study area route.](image-url)
3.4 Equipment

3.4.1 Bicycle

For the needs of the experimental study, a bicycle was used which was the same for all participants (Fig. 2). This bike, blue colored, which belongs to the trekking category, is made by Ideal and has 28-inch wheels. Also, the model’s name is Nergetic and is a 27-speed bike.

3.4.2 Eye Tracking Glasses

SensoMotoric Instruments’ eye tracking glasses were used by the riders participating in the study (Fig. 3). This device is a pair of glasses which has a camera on the front, two small cameras on the bottom to detect the movement of each eye and a microphone. The glasses are connected via a USB cable to a laptop in order to store the recording data. The connected laptop was carried by the participants in a backpack throughout the ride. In addition, for optimal integration of the system in both the environment and the driver’s face, the system includes the ability to change the lens as well as special accessories to adapt to the nose area, so that the eye cameras are raised and the eyes are centered or the opposite.

3.4.3 Navigation

Participating riders were asked to follow the instructions given to them by a smartphone navigation application, which was located on the handlebar of the bicycle (Fig. 4: left). The instructions given to the drivers were both visual (Fig. 4: right) and acoustic. The smartphone used was a Xiaomi Mi Note 10 Lite model which has a 6.47-inch screen. RidewithGPS application was used for navigation. Using the route planner feature available on the application, the predefined route was plotted and then the navigation cues were placed manually as shown (Fig. 5). After this step, a message was composed for each cue (Table 1).
Table 1 Navigation commands.

<table>
<thead>
<tr>
<th>Cue No.</th>
<th>Message</th>
<th>Route distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Turn right, then turn left</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Turn left</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Turn right</td>
<td>91</td>
</tr>
<tr>
<td>4</td>
<td>Continue straight ahead, turn right at the intersection</td>
<td>142</td>
</tr>
<tr>
<td>5</td>
<td>Turn right, then turn left</td>
<td>173</td>
</tr>
<tr>
<td>6</td>
<td>Go straight and at the end of the road sharp turn left</td>
<td>254</td>
</tr>
<tr>
<td>7</td>
<td>Turn left</td>
<td>317</td>
</tr>
<tr>
<td>8</td>
<td>Then turn left again</td>
<td>333</td>
</tr>
<tr>
<td>9</td>
<td>Go straight and turn right at the intersection</td>
<td>430</td>
</tr>
<tr>
<td>10</td>
<td>Turn right</td>
<td>460</td>
</tr>
<tr>
<td>11</td>
<td>Then turn left</td>
<td>471</td>
</tr>
<tr>
<td>12</td>
<td>Continue straight ahead</td>
<td>533</td>
</tr>
<tr>
<td>13</td>
<td>At the end of the road take a sharp right turn</td>
<td>543</td>
</tr>
<tr>
<td>14</td>
<td>Turn right and then continue your right</td>
<td>595</td>
</tr>
<tr>
<td>15</td>
<td>Continue straight ahead, turn right at the intersection</td>
<td>693</td>
</tr>
<tr>
<td>16</td>
<td>Turn right, then turn left</td>
<td>733</td>
</tr>
<tr>
<td>17</td>
<td>At the end of the road take a sharp left turn</td>
<td>813</td>
</tr>
<tr>
<td>18</td>
<td>Turn left</td>
<td>851</td>
</tr>
<tr>
<td>19</td>
<td>End of route</td>
<td>900</td>
</tr>
</tbody>
</table>

3.4.4 Navigation Problems

Due to the maps used by ride with GPS application and the accuracy of device’s GPS, navigation instructions number 8 and 13 were not activated during the navigation process of the participants, without having a direct impact on the successful execution by each rider. For this reason, the distraction times in the diagrams that follow in next chapter, for those instructions, will be zero.

3.5 Data Collection

iView ETG program was used to record the data on a laptop. Specifically, the recording of eye movement is achieved (Fig. 6) through the device’s cameras (eye-tracking glasses).

Prior to the start of the recording for each ride, a device adjustment process was required. This procedure aims at adjusting the front camera of the device as well as the eye cameras, so that the indications are correct and accurate. This was achieved by focusing the drivers’ gaze on three specific points, where the user-driver looks at a fixed point and the program operator confirms it by clicking on that point (Fig. 7). By the end of the adjustment process, the system was ready for recording.

Fig. 6 Capture of eye movement through iView.
4. Results

The data obtained from the voluntary participation of the riders were collected and analyzed after the end of the experiment. Figs. 8.1, 8.2 are related to speed in relation to the traveled distance for each participant while Fig. 9 shows speed in relation to the traveled distance for all participants. Fig. 10 is showing distraction time in relation to traveled distance (of navigation commands) while Fig. 11 shows average distraction time of all riders. Figs. 12 and 13 exhibit distraction time of riders (in each navigation command) depending on the use of bike and the experience in using navigator.

5. Conclusions

Although there is a significant reduction of road deaths in the last years, Greece remains high on the list, thus deeming the urgent need to take measures and actions in the right direction. The data of road accidents worldwide as well as the outcome of various studies, highlight the seriousness and the importance of driver’s distraction. In Greece, however, the only data available are the accident statistics as no research has been completed on the subject.

In this research, an approach in cyclists’ safety and specifically in the distraction of cyclists was made by
Fig. 8.2  Speed vs traveled distance for each ride (Vertical lines stand for navigation commands’ appearance).
Fig. 9  Speed vs travelled distance for all rides.

Fig. 10  Distraction time vs distance (Navigation commands) for each ride.
Fig. 11  Speed vs travelled distance for all rides.

Fig. 12  Average distraction time vs distance (Navigation commands) for bike users (left) and non-users (right).

Fig. 13  Average distraction time vs distance (Navigation commands) and navigator using experience. Very low navigator-using experienced riders (top left), low (top center), moderate (top right), high (bottom left), very high (bottom right).
conducted field tests. The results of the experiment performed, show us that the phenomenon of bicycle riders’ distraction is real and plays a major role in causing road accidents in urban environments. The riders glanced, several times and for many seconds, away from the driving task. Participants who are also bicycle users, moved their eyes away from driving for a longer period compared to those who do not use a bicycle. In contrast, riders who were less familiar with navigating were observed to have shorter distraction times. It is also worth mentioning that riders felt that their attention was not distracted from the driving task during their rides.

The goal of this study was to quantify distracted riding behaviors and provide a baseline assessment to assist evidence-based public education and awareness campaigns aimed at reducing distracted bicycling behaviors. In addition, we expect that this study will give information regarding the prevalence of this new bicycle safety concern within the biking community, to injury prevention specialists, local law enforcement, and state and federal highway safety agencies.

References

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