Palacký University Olomouc

Transactions on Transport Sciences
Peer-Reviewed Open Access Journal
Vol. 2/2024 DOI: 10.5507/tots.2024.002
journal homepage: www.tots.upol.cz

Activities of Car Drivers Performed During Waiting in front of Traffic Lights at Road Junctions

JOSEF BULÍČEK, PAVEL DRDLA

Universtiy of Pardubice, Faculty of Transport Engineering, Department of Transport Technology and Control, Studentská 95, 532 10 Pardubice, Czech Republic

ABSTRACT: The aim of the paper is to define activities performed by car (vehicle) drivers while waiting at traffic lights in city areas and how frequent they are. Some of these activities could be a factor leading to possible traffic accident. The research is based on the sample of 17,088 surveyed vehicles. Data were collected on 67 streets in 5 cities in the Czech Republic (Praha, Brno, Pardubice, Olomouc, Frýdek-Místek) from IV/2022 to VI/2023. The way of survey is manual data collection. There are defined and assessed 7 groups of activities – following traffic situation; cellular phone; (vehicle) control elements; talking to other people in a vehicle; paper documents; drinking+eating+smoking; and dressing-up. The modified SWOT analysis is applied in process of definition of these groups of activities. All these activity groups and their impacts on vehicle driving are discussed in the paper. The data collected are assessed in transport technology as well as statistics points of view. Means of descriptive statistics and χ^2 Goodness-of-Fit test are applied. Data are compared by city as well as by direction of drive (towards/outwards or around the city centre). The relation to the distance from the city centre is assessed in the case of Prague. Differences by drivers leaving residential areas and shopping centres are discussed, as well as the impact of tram transport. The main result is that ca. 65% of drivers still follow traffic while waiting at traffic lights. Talking to others in vehicle is recorded by 14% of drivers. Vehicle control elements are manipulated by 4%. The remaining 17% of drivers perform other (and may be riskier) activities – cellular phone 8%; drinking+eating+smoking 6%; dressing-up 2%; and paper documents 1%. From a transport technology point of view, this structure should be considered as representative. Relationships to some of the facts mentioned were recorded, but they are seen to be not so significant. The increased frequency of 'drinking+eating+smoking' and 'dressing-up' activities by leaving shopping centres can be pointed out as an example. The paper is extended by comparison between stated (in on-line survey) and revealed (on-site) preferences, with the result that people are open to allow also activities which can be problem in the point of safety (e.g. cellular phone). The paper is concluded with suggestions. First is statement, that the ergonomics of vehicles that reduce the demands on attention by performing such activities is helpful. The second suggestion is to mark specific parking places for short stops in city areas. Both suggestions are based on the fact, that ca. 21% of drivers perform activities reducing attention, and it is illusory that these activities should be totally replaced by their prohibition. It is necessary to give them the opportunity to manage these activities more safely than by waiting at traffic lights. The paper presents results of activities of students at internships between the Palacký University Olomouc and the University of Pardubice.

KEYWORDS: Activities of drivers; Car drivers; Driving a vehicle; Red ligth at intersection; Road transport; Traffic ligths; Wating at traffic lights

HIGHLIGHTS

- The paper is focused on activities performed by car drivers waiting at traffic lights in city areas.
- A transport survey of 17,088 vehicles was carried out on 67 streets in 5 cities in the Czech Republic.
- The activities performed have been clustered into 7 groups: following traffic; cellular phone; vehicle control elements; talking to others in the vehicle; paper documents; drinking+eating+smoking; and dressing-up.
- Safe activities (following traffic and talking to others in the vehicle) were registered in 79% of cases.
- Holding of cellular phone in hands was registered in 8% of cases.
- The share of activities like drinking+eating+smoking; dressing-up and manipulation with car control elements is higher near shopping centres.
- Differences between surveyed localities according to their character are not fundamental, but there are visible same tendencies, how conditions related to car surrounding impact performed activities.
- Activities like manipulation with control elements; using cellular phones; drinking+eating+smoking; and dressing-up will be hard to remove in total. It is visible by their share (frequency) and by their evaluation in the on-line orientational survey of stated preferences carried out.
- Improving vehicle ergonomics and marking of parking places for short time stops on city roads with limited possibilities of other ways of parking are suggested as potential measures that help to increase the level of attentiveness of drivers as a way, how to also prevent traffic accidents.

1. INTRODUCTION

Waiting in front of traffic lights at signalised road junctions is one of the few opportunities to relax by driving a car (vehicle) in the city area. It is almost only one opportunity to perform such activities like drinking, eating, radio or air-condition setting, etc. in a relatively safe way. On the other hand, this waiting time is strictly ended by a change of signal at the traffic lights with the need to react flexibly. Performing different activities than driving could decrease the attentiveness of a driver. Decreased attentiveness can lead to extension of the reaction time or to traffic accident in an extreme case. This risk is increased when drivers continue in activity after starting the drive, it means by passing a junction.

The main aim of this paper is to define the activities that drivers perform while waiting in front of traffic lights at signalised junctions and how frequent they are. Discussion about these activities and the factors that lead to them is also incorporated. The paper is equipped by rapid comparison of stated and revealed preferences in this field.

For characterisation of the context, two brief suggestions – highlighting of car ergonomics and reservation of some parking places for performing of potential risky activities at rush streets are mentioned. Reaching of some final solution is not the aim of this paper. It is identification of possible starting points for balancing the relation between needs of drivers and needs of transport operation.

Understanding what happens in vehicles by driver during waiting is needed from different perspectives:

- Well-being of drivers
- Ergonomics
- Traffic organization
- Safety

The well-being of drivers is connected with attentiveness and, finally, with the safety of driving. Traffic organisation is the most complex perspective. The prompt responses of drivers are the presumption of the efficiency of the measures leading to the improvement of the capacity of the road infrastructure. Possibly delayed reaction can lead to communication problems between waiting drivers.

An innovative approach is seen in the fact that these activities are considered not only from a risk point of view. This paper should create a starting point for further research to see why people perform these activities by waiting at traffic lights. It is true that this objective is more general than the aim of this paper, but it is needed to mention this for the possibility of considering our research in a wider context. The problem is that similar topics are often solved in a way like 'it is restricted'; 'it is for safety'; 'do not break the rules'. The high importance of such principles will not be reduced, but it is needed to solve the issue of surrounding conditions.

One of the basic rules of road transport is to adopt the style of drive according to the conditions. For example, to stop the vehicle at an adequate place when it is needed. For instance, need to turn head and to communicate with children on rear seats or manipulation with a bottle of water can be such cases. The issue is how current traffic conditions support such responsible decisions. In other words, how easy is it to find a place to stop or is it replaced by waiting at traffic lights as an alternative option for such activities. This is the reason why relations between type of locality and volumes of individual activities are assessed in this paper.

Research is focused on the city areas of the Czech Republic. Transport surveys were carried out on 67 streets closed by traffic lights in 5 cities of the Czech Republic. There are 2 regional centres Pardubice, Olomouc with rush traffic involved in the survey. Next to it, there is the capital city of Praha (Prague) and the second most populated city of Brno. Both couples create possibility to compare results. The last locality of Frýdek-Místek is added for the purpose of rapid check. The total number of vehicles surveyed is 17,088.

Data collection is based on observation of vehicles waiting at traffic lights from outside. This was performed in manual way. Technology supported ways of surveying (e.g., video detection and recognition) were not applied. Data evaluations and situation assessments are performed from 2 points of view. The first is transport technology (using means of descriptive statistics). The second point of view is statistical (based especially on χ^2 Goodness-of-Fit test).

An important part of performed transport surveys (31.9% of vehicles surveyed and the Internet survey of stated preferences) has been carried out by the students of the Palacký University Olomouc. This is realised in the framework of long-time cooperation between the Faculty of Arts, namely the Department of Psychology (the Palacký University Olomouc) and the Faculty of Transport Engineering, Department of Transport Technology and Control (the University of Pardubice). This cooperation connects students of psychology (in the field of psychology of work and organisation, including transport psychology) with transport issues. Motivation can be illustrated by the general topic of collective research intent called 'A man in a transport system'. Therefore, the secondary objective of this paper is to present a part of the results of this cooperation as well. The data was collected from April 2022 to June 2023 by three runs of student internships. The rest of the surveys were realised by the authors of this paper coming from the Department of Transportation Technology and Control. It is not a standard research project. For that reason, research possibilities (especially research extent) are limited for this reason.

2. STATE-OF-ART

2.1 Legal framework

In the Czech Republic, there is valid the Act No. 361/2000 Coll. (Road Operation Act) in the current version. The main rules from the given point of view are the following.

The driver of a vehicle (car) is obligated to be fully focused on driving and observing the traffic situation. Other people in the vehicle do not endanger the safety of road traffic; they do not restrict driver in the safe control of the vehicle. The holding of cellular phones or similar devices by the driver is prohibited while driving. Phone calls realized by hands-free devices are allowed.

It can be summarised that not all activities surveyed are banned, but all of them can be also a legal problem if they threaten safety.

2.2 Literature review

Controlling of road traffic by traffic lights is a well discussed topic. The paper created by Scandella, Ghosh, Bin, & Parisni (2022) is focused on driver decision making by selecting route through cities according to invited time spent due to waiting at traffic lights. This is the opposite side of our topic – network point of view.

The paper by Yang, Wang, & Nakano (2022) is focused on progressive technology how virtual traffic lights incorporated in vehicles can help control traffic at unsignalized road junctions. This technology is based on vehicle-to-vehicle communication.

Some research activities are also focused on algorithms on how to control traffic lights. For example, Radivojević, Tanasković, & Stević (2021) presents an adaptive algorithm for this control at junctions with 4 connected streets and with 4 signalling phases in a cycle. Cycle duration, green-light duration, and duration of phases can be adjusted to current traffic situation with an effort to minimise congestion and time of delay.

Assessment of traffic situation at road junction using simulation is presented by Ramirez-Polo, Jimenez-Barros, Narváez, & Daza (2022). The research was carried out on heavy loaded roads in the city of Barranquilla, Colombia. Possibilities to optimise the times of individual signals, as well as to optimise the cycle length, are also presented.

Some of the connected effects are also researched, such as the possibilities to reduce pollutant emissions Jame, Rapelli, & Casetti (2022) by adjustment of operation of traffic lights. Virtual traffic lights are applied, but the core is the same – relationship between the need to stop and the level of pollution.

The interaction between left turning vehicles and pedestrians at a signalised junction is the focus of the article He et al. (2019). The relationship between traffic efficiency and safety is estimated.

The role of countdown timer is assessed in by Małecki, & Iwan (2019). Impact of information on how long time remains to the signal change is investigated by using a simu-

lation model based on cellular automaton and multi-agent technology. The result is that the countdown timer contributes to proper reactions of drivers and to better utilisation of a junction capacity.

Modelling of traffic operation at road junction is quite common task, including Czech conditions as it is presented by Beneš, & Ledvinová (2014). These models need to be extended to allow one to model the relation between performed activities and way of subsequent driving. For example, similar extensions from the field of air transport are presented in papers by Široký, & Hlavsová (2018) or Kovačič, Doler, & Sever (2021). Both these papers deal with incorporation of specific features into the model. The first is focused on passenger check-in and the second on the technical condition of a runway. Data collected at junctions in this research possibly could be a first and initial step for creating the data sets needed, allowing such an extension of road junction models. The way in which to model multicriterial decision making of drivers can be inspired for instance by the paper prepared by Kleprlík, & Matuška (2017) focused on decision making of public transport passengers.

2.3 Similar studies

The topic presented by Palat, & Delhomme (2016) is focused on risky behavior of drivers in front of a junction or by passing a junction. The violation of traffic rules is also mentioned, but in a different context than by our research. Simulator study of factors influencing driver behaviour at traffic lights is the base. There were 96 drivers involved in the study. Driving under and without time pressure was simulated. The aim of the study was to find measures that lead to reduction of driving with yellow light and rapid accelerations. This research was focused on factors coming especially from outside (e.g. from interaction with other vehicles) with the exception of one effect, driving in a hurry. Our research is focused on activities performed from inside by the decision of the driver.

More complex research in this field is presented by Felicio, Grepo, Reyes, & Yupingkun (2015). A case study from the Philippines assesses different ways to provide traffic signals. The results are that 99.5% of drivers respect red signal and try to stop; 98.2% of drivers drive at same speed or accelerate at green signal and 76.3% of driver try to decelerate at yellow. This shows that traffic lights are well-respected by drivers. The research is also focused on the effect of various warning signals such as blinking lights, countdown timers, etc. Any of such warning signals is applied on traffic lights in the Czech Republic, where our survey has been conducted. There are the countdown timers applied exceptionally for pedestrians or at mobile traffic lights switching traffic direction in the case of construction works in the Czech Republic.

Salvia et al. (2016) assess reactions of drivers on changes of signals at traffic lights. Understanding the signal is mentioned as well. The article is focused on older and middle-aged people only. This is one of the differences from our research, because in our research there are drivers of all age categories (able to drive a passenger car; ≥ 18 years old) involved in our research. The second difference is that Salvia et al. (2016) is focused only on the traffic lights signal; our scope of activities is wider.

Chen, Nyazika, & Singhal (2016) studied the impact of the presence of a fellow passenger in a vehicle on driver attention. The capacity for attentiveness of driver is divided between driving and communication with other people in vehicle. This can be a potential complication by solving more difficult traffic situations. For that reason, the 'adequacy' of interaction with others is highlighted in our research presented in this paper.

Activities like working with paper documents and making phone calls while driving are assessed in the material presented by Laurier (2001). This material deals with driving in general during the entire drive (not at traffic lights only).

A very close topic is presented by Huth, Sanchez, & Brusque (2015). The use of a cellular phone at traffic lights is highlighted as a core activity. This activity is assessed in detail, including surveying of strategies and how cellular phones are used. A similar data collection methodology (personal observation) was applied. The research was conducted in Lyon, France. The second important difference is that our research is carried out in more cities (5) and local conditions determined by the surroundings of the surveyed junction are considered to create a part of the research framework.

Interesting activity in the field of safety at junctions was conducted and presented to wide public by the regional journal named Příbramský deník in the work of Seifert (2009). Important junctions in the city of Příbram (population ca. 33,000 inhabitants; located ca. 60km from Prague to the southwest) were assessed by the police, driving school lecturers, representants of drivers and journalists. The results can be generalized – the junctions can be passed in relatively safe way, but it requires paying attention.

Road infrastructure managers often deal with the topic, how to improve safety, especially in constructional point of view. For example, which junctions should be modified (construction of roundabouts, installation of traffic lights, extension of number of lanes, modification of traffic signs etc.).

Reaction time of drivers with natural limitation of the visual field (e.g., seniors) on stimuli along the roads has been researched by Bouchner et al. (2016). Research conducted at the Czech Technical University measured values of reaction time by using car simulator and technical equipment like eye trackers. Traffic lights are not included. The most similar case is reaction on signalization of a rail crossing.

3. ACTIVITIES OF VEHICLE DRIVERS WHILE WAITING AT SIGNALIZED JUNCTIONS

There are activities of vehicle (car) drivers divided into 7 defined groups of activities according to its similarity. The following subchapters 3.1 – 3.7 are dedicated to their introduction.

Modified SWOT analysis is applied with the aim of discussing positive and negative effects influencing road traffic. Modifications of the SWOT analysis are applied in this way:

- Strengths are replaced by factors that support road traffic safety.
- Weaknesses by factors able to improve risk and inattention of drivers.
- Opportunities by targets able to be reached when the activity will be performed while waiting (in comparison with performing while driving).
- Threats are dedicated to possible negative impacts able to occur when the activity will be performed.

3.1 Following traffic situation

Many drivers remain attentive like they will continue driving. They still hold a steering wheel, they do not significantly move with head, etc. This situation is also preferred by the Act No. 361/2000 Coll. – to pay attention to traffic (in the Czech Republic).

S: Drivers are concentrated.
W: There are almost no negative effects from the point of view of safety.
O: Drivers can react to signal changes in an appropriate, prompt, and flexible way without time loss.
T: Drivers should be "overmotivated".

The threat marked as "overmotivation" is invited by drivers in a hurry and by drivers with deep knowledge of the time schedule, how the signals are changing. These drivers should follow the work of the traffic lights as system and they can anticipate start of the green signal according to other related effects than the signal itself (e.g. by end of the green signal in other direction). The negative effect can occur when the signal will be switched in an unanticipated way (e.g. by drive of preferred tram – with priority – in drive) and the signal valid for the driver will remain red.

It must be correctly admitted that one specific error is related to this activity. Naturally, it is impossible to observe from outside if drivers are concerned on traffic or if they think about their personal worries or pieces of news coming from radio etc. It is difficult to eliminate this effect. When the drivers know about the survey, they behave in different way. For that reason, it is necessary to accept this error and to take it into account in interpretation of results.

3.2 Cellular phone

The holding of a cellular phone in the hand of the driver is negative even though it is done while waiting in front of a signalised junction. Holding of cellular phone in hand by driver while driving is prohibited by the law.

S: The use of a cellular phone while waiting at traffic lights should reduce the possible negative effects that impact safety.
W: Attention is paid to a cellular phone and not to a traffic situation.
O: Effort to minimise the use of the phone during active driving (even though this activity is negative anytime).
T: Reactions on signal changes can be delayed, and subsequent driving manoeuvres could be done quickly without deep recognising of the traffic situation and with limited concentration. Continuation of call during crossing the junction could also be a risk.

3.3 Control elements

Manipulation with vehicle control elements (switching of them) is allowed and sometimes necessary. On the other hand, it can also be a source of inattention. It is impossible to differ from outside if this manipulation is necessary (e.g. electronic setting of rear-view mirrors) or voluntary (e.g. setting of air-condition, switch of a radio station, or control of a car navigation device). Making phone calls using hands-free sets belongs to this category.

S: The ergonomics of vehicle control elements is often designed for quick and easy manipulation conditions (not to disturb a driver a lot).
W: The increased volume of control elements and the increasing frequency of manipulation with them.
O: Aggregation of information systems (e.g. navigation) with vehicle control elements and well-organised interface of them can save time of driver.
T: Increasing volume of tasks different from driving for drivers.

3.4 Talking to others in vehicle

Talking to other people in vehicle is safer than telephone call because people in vehicle know vehicle position, see traffic situation and they often adapt the conversation to the conditions. It is necessary to communicate on adequate level because discussion of complicated topics, quarrels, too much intensive way of talking, etc. can also decrease driver attention. On the other hand, talking to others can also have positive effects like prevention to fall asleep; option to be notified on risky situation in traffic (if they are presented in an adequate way); possibility to transfer navigation role to a fellow passenger, etc.

In an extreme case, serious disturbing of the driver can be considered as a violation of the Act No. 361/2000 Coll. (in the Czech Republic).

S: Talking to others can prevent a driver from sleeping.
W: Complicated topics and inadequate dialogues can stress the driver and can decrease attentiveness.
O: Talking should be adjusted to traffic situation (interrupted at complicated places); reflecting traffic should possibly help to driver in complicated traffic situations.
T: Talking should keep the driver busy.

3.5 Paper documents

The importance of this activity (working with paper documents) is decreasing. It is typical for lorry drivers in delivery services.

This group was extended by some activities like searching for parking cards in handbag, for coins to be inserted into slot machine at a parking lot or into a supermarket trolley etc.

S: Stopping of the vehicle while waiting should make the activity possible.
W: Manipulation with papers (turning pages, need to hold a pencil, etc.) should be complicated.
O: This activity will make the stop at the next place (by next addressee) shorter. It can help to meet time limits or to reduce the total duration of drive (distribution).
T: Driver should have some documents or things in hands during start of riding if the activity is not finished before switch of the signal. There can be a potential stress coming from incompleteness (need to return to the document and need to search for incomplete fields in paper form; risk that the handbag content should be spilt, etc.).

3.6 Drinking, eating, smoking

Eating, drinking, and smoking should be considered as part of physiological needs. Physiological needs are more important than safety according to the Maslow pyramid of needs published by Gherman (2012).

S: Stopping of the vehicle while waiting should make the activity possible.
W: Manipulation with packaging (opening bottles, etc.) should be complicated.
O: Hunger and thirst can cause significant stress when these activities are avoided. The potential stress should be reduced in this way.
T: Hot drinks or smoking can cause serious injury. This could also be very dangerous for road traffic (almost total loss of attentiveness to drive possible).

Total avoidance of these activities could be not an efficient solution (e.g., feeling hungry could be a stress as well), better ways how to realize these activities should be found.

3.7 Dressing-up

Finally, there are activities related to dressing-up (modification of clothing). It means, for example, turning on the jacket, putting down the sweater or tie modification. Adjustments of hair or eyeshadow are also included. The application of deodorants and perfumes, the use of lipsticks, the sweet-wiping, or the cleaning of glasses belong also to this group. This group is also extended by activities related to stretching oneself. Small exercise has similar needs on attention, movement, etc.

S: Stopping of vehicle while waiting should allow activities that require free hand. Dressing-up and stretching belong to such activities.
W: Continuation of activity after the start of the drive. Complication especially by dressing-up. Potential stress from the fact that dressing-up is not finished (from incorrectly dressed clothes, e.g., untied tie, need to drive in clothes not corresponding with temperature, e.g., in T-shirt in winter or in jacket in heated vehicle, etc.).
O: Small stretching can help to be concerned in the following phases of drive.
T: Possible time stress, when these activities are performed in inadequate extent (e.g. effort to dress-up sweater and to drink together).

4. RESEARCH DESIGN

On-site observation of cars waiting in front of traffic lights with an effort to survey prevailed preferences takes the main part of the research. This is equipped by additional on-line survey focused on stated preferences. Details to this additional survey are in the chapter 6.

4.1 The way of surveying

The main research is based on on-site observation of traffic. This survey is focused on drivers of passenger cars and lorries (minivans). Other vehicles were included in the case when the conditions of the driver were like this situation. For instance, when vehicles of integrated rescue system (ambulance, police car) have driven without using of priority signalling and when they have driven in a similar style (same speed) as other vehicles, they were involved. On the other hand, when they had driven with signalling, the survey was interrupted. It also has an impact on the behaviour of other drivers. Drivers of public transport vehicles are excluded due to different working conditions (separated cabin, obligation to observe situation on board, etc.).

The research conducted is based on personal observations. These observations were performed from outside of vehicles. No contact with drivers was established. So, it was impossible to collect additional information in oral or written form. This way of surveying is still advantageous from three points of view. The first is that a person can efficiently and quickly decide about the kind of activity performed. The second is the privacy of drivers and of other people in vehicles, because no audio-visual recordings were obtained. Subsequent identification of vehicles or persons is not possible due to this. The third advantage is easier and more flexible movement of the person during surveying to obtain better visibility in vehicles. This is expressed in comparison with cameras placed on tripods, etc.

Data are noticed in a survey form. There are columns for individual monitored activities. One dash is written for one vehicle. Other symbols should be applied to differ individual sub-activities within one category evaluated together, e.g., drinking, eating, or smoking. When the driver performs more activities together, the dominant one is marked only.

In the case where the activity is not recognised, no record is made. It can be caused by several reasons, such as covering the vehicle by another vehicle; sun backlight; dark car windows or lack of time (when the traffic is too rush). The omission of a vehicle from the survey is possible for this objective reason only. This is possible because the intensities of traffic flow (number of vehicles per time unit) are not evaluated.

The method of determining the extent of the survey has evolved. The first 25% of the streets surveyed were based on the principle of time. Each street was surveyed for 120 minutes. So, the number of vehicles surveyed was different from 185 to 547 vehicles on one street (per 2 hours). This also guaranteed fair conditions for participating students. On the other hand, this has no significant impact on the conclusions. The switch to limiting by number of vehicles has been made. This change was efficient from an organisational point of view. The rest of the streets were surveyed in the way 180 vehicles were surveyed in each street. On the rush streets, where this volume of data was collected in a short time (about ca. 40 minutes), the survey was extended to 240 vehicles.

The evaluation is based on relative values (in percentage) due to the different number of vehicles surveyed on different streets. This makes the results comparable.

4.2 Selection of surveyed localities and streets

The survey was carried out in five cities in the Czech Republic. Major cities are represented by Prague and Brno (2 most populated cities), regional centres by Pardubice and Olomouc. Couples of cities are selected for possibility to compare them. There is one street (in one locality) surveyed in Frýdek-Místek only. This is applied especially for validation purposes – to get rapid information from different operational conditions.

Total number of surveyed localities is 34. Locality means a place within the city; road junction is a typical example. An example of a locality is presented in Fig. 1. There were surveyed two junction entries (streets) - outwards (Fig. 1a) and towards (Fig. 1b) the city centre.

Fig. 1a and Fig. 1b Example of locality (junction) Brno-Semilasso consisted of 2 surveyed streets. Source: photo Authors

The number of streets surveyed ranges from 1 to 5 in individual localities. The summary of this survey is provided in Table 1.

All these localities are related to rush places located usually on main roads or at exits from commercial zones with shopping centres.

City	Population	Localities	Streets	Vehicles
Praha (Prague)	1.2m	21	46	10841
Brno	389k	4	7	1560
Pardubice	90k	2	5	1718
Olomouc	110k	6	9	2759
Frýdek-Místek	66k	1	1	210
Total		**34**	**68**	**17088**

Table 1. Survey extent according to cities. Source: mesta.obce.cz + Authors

4.3 Privacy

The protection of privacy and anonymity for all the surveyed persons is a key factor. No audio-visual records were made during the survey time. It means that vehicles in figures (used in the paper) are not taking part in the survey. These photos were taken outside the survey period. The main identification symbols (like car plates) were also replaced in these figures.

No data allowing personal or vehicle identification (like car plate number, detail description of vehicle, company name, etc.) were collected (written) during the survey. Data were written manually – one dash (or letter) identifying activity for one vehicle.

The age and gender of drivers are not surveyed. The objective of the research is to survey the kind and frequency of activities in relation to (transport) conditions in the surroundings of surveyed locality (e.g. direction to/from the city centre). It is true, that there can be invited some possible relations between these features. These relations are important for example for communication strategies in the field of accident prevention, but for our current research it is a new degree of freedom. Time needs related to manual writing of data on site are also one of reasons, why gender and age have not been recorded during surveys.

The surveys were carried out openly. People surveying traffic with paper forms stood on the pavement (or sat on the bank) close to the road, and they did not hide. They did not use any equipment like binoculars, cameras with telephoto lens, etc. Therefore, the view of the vehicles was the same as that of any other pedestrian. When someone has contacted (orally, gesturally) the surveyor, the vehicle was not registered. It is due to 2 reasons. The main is effort to respect possible disagreement. The second is that the person who is communicating can possibly change planned activities due to this communication. This rule was applied to all people in a car.

The duration of observation of one vehicle is in seconds. The maximum waiting time is related to the signalling cycle of the traffic lights. The length of this cycle is usually between 60 and 90 seconds. There are usually more vehicles in front of traffic lights together. Number of vehicles registered per one red light was set according to local conditions, it means possibility to recognize the activities. Finally, the surveyor must register hundreds of vehicles. The possibility of recalling details is minimal in this case. This makes this observation comparable with the possible observation by pedestrians walking around or waiting in front of a zebra crossing. The authors believe that the potential intrusion into privacy is minimal.

4.4 Data evaluation and assessment of situation

The collected data are assessed in two ways. The first is in a transport-technological way, where the data are discussed by means of descriptive statistics such as quantities and maximal, minimal, or average values, etc. The main focus is put on the evaluation with regard to transport context.

The second way is statistical. This way is based on χ^2 Goodness-of-Fit test. This test is performed for a mutual comparison of individual streets or of sets of streets.

In general, the tested hypothesis H_0 expresses that differences are the result of chance. In other words, individual groups of activities will have a similar share on both of compared (groups of) streets. Hypothesis H_1 expresses that there is a different reason leading to different values of shares.

Some surveyed groups of activities (categories) had to be merged for statistical assessment. It is caused by the low frequency of some activities (including the value of 0) in some of the streets. The manipulation with control elements had been merged with the paper documents. The activity of drinking, eating, and smoking has been extended by dressing-up (and stretching).

Activities indicating contact in the vehicle and following of traffic had been totally excluded from statistical testing. It is because these two activities are related to next factor - if there are other fellow passengers in the vehicle or not.

The χ^2 Goodness-of-Fit test was performed in Microsoft Excel software. This process consists of 2 steps. The first is the specification of the estimated numbers of activities. In general, these numbers are also based on values obtained by preformed transport surveys. These values are adjusted to make the same total as is the total number of activities registered on assessed street (or group of streets). The second step is related to the calculation of the test value. This value is called the p-value. When the p-value is higher than or equal to the value of significance level α, hypothesis H_0 is not rejected. Practical interpretation is that there is no reason to reject the idea that the shares of activities are similar and potential differences are caused by random impacts only. The significance level applied within this investigation is $\alpha = 0.05$.

The specification of individual comparisons is presented together with results in Chapter 5.

5. RESULTS

The total number of vehicles surveyed is $N = 17{,}088$. The positive fact is that 65% of drivers are concerned with traffic situation also while waiting at traffic lights and 14% of drivers talk to other people in vehicle. Therefore, 79% of drivers perform relatively safe activities. 8% of drivers take their cellular phone into their hands. The remaining part of 12.8% of drivers perform one of the other monitored activities.

5.1 Comparison of cities

Transport technology point of view

The data obtained can be expressed according to individual cities; see Figure 2. There are similar proportions of individual activities in individual cities. The assessment from transport technology point of view is made for all streets in individual cities, including those that exits from shopping centres.

The major share belongs to drivers following traffic situation. The share of holding a cellular phone in hand ranges from 5.71% (Frýdek-Místek) to 8.88% in Prague. The comparison of all the activities provided in numbers is shown in Table 2.

The small share of working with paper documents corresponds with the fact that these documents have decreasing importance in current time.

Statistical point of view

The results of the statistical assessment performed using the way of χ^2 Goodness-of-Fit test for the statistically assessed activities (see Chapter 4.4) are in Table 3. Assessed cities with real values are in lines, and compared cities providing estimated values to the test are in the columns. Streets that exit

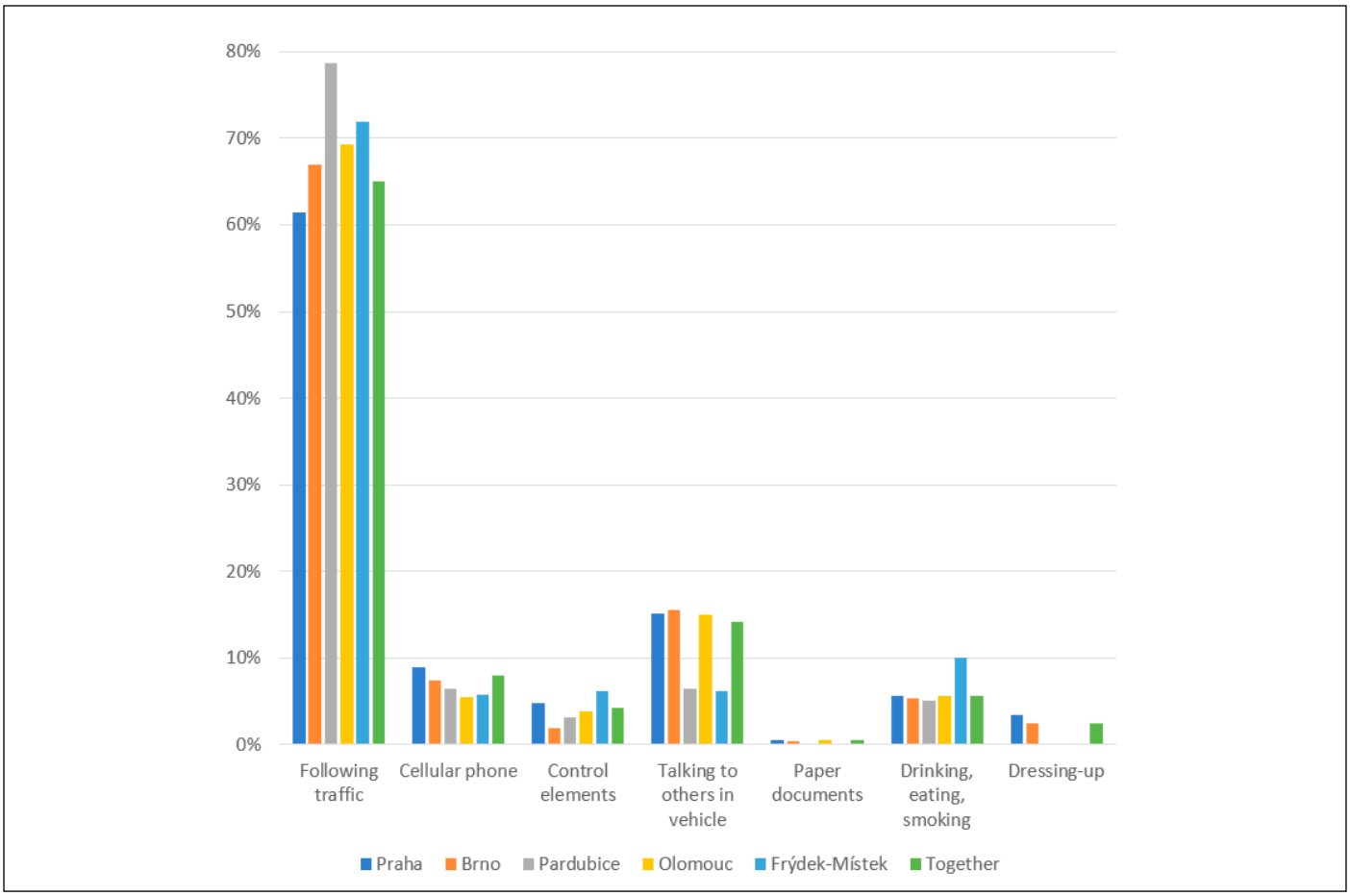

Fig. 2 Share of individual activity groups according to cities. Source: Authors.

Place	Following of traffic	Cellular phone	Control elements	Talking to others	Paper documents	Drinking, eating, smoking	Dressing-up
Maximal	78.64%	8.88%	6.19%	15.51%	0.58%	10.00%	3.43%
Average	**69.65%**	**6.81%**	**4.00%**	**11.68%**	**0.32%**	**6.33%**	**1.21%**
Minimal	61.47%	5.47%	1.92%	6.19%	0.00%	5.06%	0.00%
Variation range	**17.17%**	**3.41%**	**4.27%**	**9.32%**	**0.58%**	**4.94%**	**3.43%**

Table 2. Share of activities. Source: Authors

p-values [-]	Compared to the city:				
Assessed city:	**Brno**	**Frýdek-Místek**	**Olomouc**	**Pardubice**	**Praha (Prague)**
Brno		$1.0095 \cdot 10^{-7}$	0.001872513	0.006968658	0.010047536
Frýdek-Místek	0.009045674		**0.301142222**	**0.053248909**	**0.189453996**
Olomouc	$8.10062 \cdot 10^{-9}$	$2.19761 \cdot 10^{-5}$		0.034137056	**0.582947042**
Pardubice	0.000227265	$9.70754 \cdot 10^{-10}$	**0.07288579**		**0.324798369**
Praha (Prague)	$3.15223 \cdot 10^{-35}$	$1.41667 \cdot 10^{-42}$	0.036779021	$9.95116 \cdot 10^{-5}$	

Table 3. Results of the χ^2 Goodness-of-Fit test – comparison of cities. Source: Authors

from shopping centres are excluded in the case of statistical assessments. It is because it is statistically tested that activities in these cases are different (for details, see Chapter 5.5).

The following conclusions can be made based on Table 3. Statistical testing is naturally stricter than technological assessment. The main result is that data from Prague, Pardubice, and Olomouc are similar with the exception of comparison between Olomouc and Pardubice. It is indicated by *p*-values > 0.05 (written in bold style).

The issue is that the data collected in Brno are statistically different from the data obtained in other cities. May be, it can be caused by a small number of drivers switching vehicle control elements or reading paper documents. On the other hand, drinking, eating, smoking, and dressing-up activities are more common in Brno.

5.2 Impact of direction of drive

The next issue is to compare the results according to the direction of the drive. Three directions are differed: towards the city centre; outwards the city centre and around the city centre.

There were 19 streets surveyed in direction towards the city centre (13 in Prague; 2 in Brno; 3 in Pardubice; 1 in Olomouc).

There were also 19 surveyed streets in direction outwards the city centre (14 in Prague; 1 in Brno; 2 in Pardubice; 1 in Olomouc and 1 in Frýdek-Místek).

Direction	Place	Following of traffic	Cellular phone	Control elements	Talking to others	Paper document	Drinking, eating, smoking	Dressing-up	Number of vehicles
TOWARDS centre	Total	66.09%	8.47%	3.84%	12.46%	0.40%	5.92%	2.82%	4509
	Prague	62.01%	9.52%	4.22%	13.71%	0.54%	5.99%	4.01%	2940
	Others	73.74%	6.50%	3.12%	10.13%	0.13%	5.80%	0.57%	1569
OUTWARDS centre	Total	68.15%	7.70%	4.10%	12.56%	0.57%	4.80%	2.11%	4873
	Prague	63.01%	8.85%	4.67%	14.95%	0.73%	4.91%	2.88%	3298
	Others	78.92%	5.27%	2.92%	7.56%	0.25%	4.57%	0.51%	1575
AROUND centre	Total	63.59%	7.57%	4.54%	16.83%	0.45%	5.01%	2.01%	5532
	Prague	58.72%	9.00%	5.78%	17.71%	0.53%	5.16%	3.09%	3043
	Others	69.55%	5.83%	3.01%	15.75%	0.36%	4.82%	0.68%	2489
Coefficient of variation		0.10	0.22	0.26	0.26	0.47	0.10	0.72	

Table 4. Activities according to direction of drive. Comparison of Praha (Prague) with other cities. Source: Authors

	Compared to:					
***p*-values [-]**	**Praha (Prague)**			**Out of Praha (Prague)**		
Assessed direction:	TOWARDS	OUTWARDS	AROUND	TOWARDS	OUTWARDS	AROUND
TOWARDS centre		0.000935278	$1.98033 \cdot 10^{-5}$		**0.45749944**	**0.552306398**
OUTWARDS centre	0.000559853		**0.33673635**	**0.480325198**		**0.975759737**
AROUND centre	$2.74459 \cdot 10^{-6}$	**0.325610479**		**0.393289495**	**0.958867958**	

Table 5. Results of the χ^2 Goodness-of-Fit test – comparison of directions of drive. Source: Authors

Finally, 20 surveyed streets are in the direction around the city centre (12 in Prague; 2 in Brno; 6 in Olomouc). Such streets are perpendicular to the main roads that connect the city centre with the surroundings of the city. Relative different numbers of streets in the case of Olomouc are caused by the fact, that there is inner city ring road creating main round serving city centre and central business area.

Because the total numbers and the numbers for Prague are almost proportional, the data are presented from three points of view – total; Prague and other cities. Table 4 contains an overview of the results.

The coefficient of variation v_x mentioned on the last line of Table 4 is calculated for the categories 'Prague' and 'Others' (not for total numbers). The highest number of this coefficient of variation v_x (ratio of the values of standard deviation and average) is for dressing-up activity group. It leads to the idea that the frequency of this activity should be related to the direction of drive, because an average value does not correspond to individual values (if $v_x \geq 0.5$). When the individual values (Table 4) for 'Dressing-up' are compared, it is seen that the reason can be different. There is a visible relation to the location of the street (Prague or other cities). On the other hand, the highest value (4.01%) is on arrival in the city centre of Prague, but this is not too much significant difference.

Statistically, there is no significant dependence on between directions towards, outwards, and around the city centre in cities out of Prague. It is due to the fact that the hypothesis H_0 – possible differences are only random – has not been rejected by χ^2 Goodness-of-Fit test. All p-values are higher than or equal to $\alpha = 0.05$ in this case (right part of Table 5).

On the other hand, the statistical difference is indicated in Prague. Values surveyed in direction towards centre are different than values in directions outwards and around the city centre; however, these directions (outwards and around) seem to be similar (see left part of Table 5).

5.3 Impact of distance from city centre

There were surveyed 39 streets at 17 localities in Prague; see Fig. 3. The idea of this part of research is how locality characterised by distance from the city centre impacts frequency of individual activities. Distances are measured from the junction of Wenceslas Square (Václavské náměstí) and the street Na Příkopě (metro station Můstek). This place is commonly denoted as the middle of the city. This place is marked by red concentric ellipses. Other numbered marks create an overall illustration about the distribution of survey sites.

The results are interpreted by Fig. 4. It is visible that the probability values of individual activities depend more on the type of activity than on the distance from the central point. It is visible that this factor is not significant despite the fact that, e.g. volume of phone calls could be invited higher in the city centre due to need to manage phone calls before reaching of destination or shorty after start of drive.

It is necessary to be added that the trend lines in Fig. 4 are displayed for simpler orientation only. They connect points representing individual streets. These points are crucial only (these values were surveyed). The mathematical interpretation of the trend lines should be inadequate.

On the other hand, mathematical consideration of distance should be too rigid. The idea that activities should be influenced by the surroundings could be more generalised. So, there can be created 3 zones. These zones have been designed and distances have been set according to specific conditions of Prague for the purpose of this research.

The inner zone covers streets close to the city centre up to 1.6km from the central point. It is assumed that the localities in the first zone belong to the most complicated transport places and a significant part of the drivers are at the beginning or at the end of their journey.

The middle zone represents the streets in the belt from 1.6 to 4.5 km from the central point. The localities in the second zone represent rush places, where a large part of the drivers is also short after start or before the end of the drive, but the share of drivers transiting here is invited to be higher.

The outer one is dedicated to the streets farther than 4.5 km. These streets are in suburban areas. There are some 'transit' streets or local junctions. In general, drivers are invited to drive longer to their destination from passing such a junction (in both directions – towards and outwards the city centre). Example of street in outer zone is in Fig. 5.

Fig. 3 Surveyed streets in Praha (Prague). Source: Authors by using of map server Mapy.cz. (Mapy.cz, 2023)

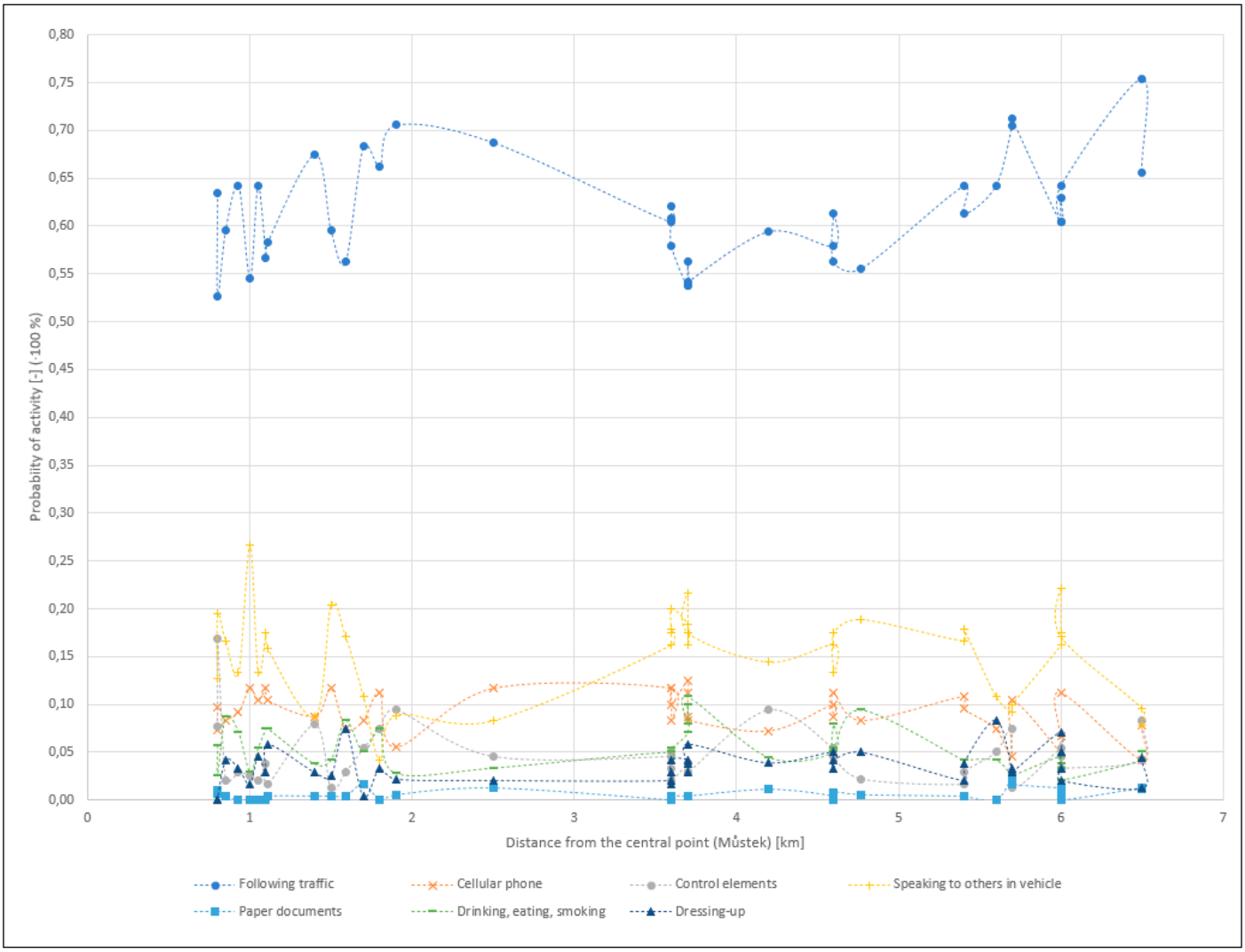

Fig. 4 Probability of activities at streets of Praha (Prague). Source: Authors.

Fig. 5 Example of street in the outer zone (Prague-Bucharova St.; 6.5km far from the city centre). Source: photo Authors

Zone		Streets	Vehicles	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking, eating, smoking	Dressing-up
1	Inner	**11**	**2921**	59.26%	9.52%	5.68%	16.67%	0.41%	5.55%	2.91%
2	Middle	**13**	**3000**	60.80%	9.87%	4.80%	14.90%	0.50%	6.10%	3.03%
3	Outer	15	**3360**	63.48%	8.10%	4.29%	14.91%	0.86%	4.46%	3.90%

Table 6. Activities in Praha (Prague) according to zones. Source: Authors

Street	Vehicles	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking, eating, smoking	Dressing-up
Musílkova	**180**	59.44%	7.22%	9.44%	14.44%	1.11%	4.44%	3.89%
Total - Prague	**9281**	61.29%	9.12%	4.89%	15.46%	0.60%	5.33%	3.31%
Total - all localities	**17088**	65.09%	7.92%	4.23%	14.20%	0.50%	5.64%	2.42%

Table 7. Activities in Praha (Prague) according to zones. Source: Authors

The results are aggregated in Table 6. It is visible that the probability of traffic following increases in the middle and outer zones, because holding a cellular phone, manipulating vehicle control elements and talking to other passengers in the vehicle is more common in the city centre, as presupposed.

The quite reverse situation is by dressing-up. It can be related to the fact that drivers want to stretch before entering rush areas in the city or when leaving such an area driving outward. On the other hand, it is necessary to mention that the difference is only 1%. Therefore, this can be explained logically but not statistically.

The results of χ^2 Goodness-of-Fit test show that hypothesis H_0 has not been rejected in any of all pairwise comparisons.

5.4 Departing from residential areas

This part of the research is additional, because one street on depart from residential area was surveyed only. On the other hand, this street has been chosen with purpose. It is Musílkova Street located in middle zone of Prague (4.2km far from the central point). Number related to this street is 16 on map in Fig. 3. The survey was carried out at the end of the AM traffic peak (8.30 – 9.30).

Table 7 shows that there is a tendency to manipulate with vehicle control elements here; the share is almost 5% above average. This could be related to the fact that drivers are for short time in vehicles here and often is necessary to accommodate rear-view mirrors, position of seat, to set air condition or to open window etc. Dressing-up is also above average, it is connected to leaving home. Subjectively frequent was also eating (breakfasting), but in numbers this activity is below average. So, some specific tendencies can be found.

5.5 Shopping centres exits

The survey carried out by students in the Olomouc-Wittgensteinova Street brought the inspiring result that drivers leaving the shopping centre prefer activities such as manipulating (vehicle) control elements; talking to other people and drinking+eating+smoking more frequently than in other localities. So, this research was extended to 10 streets located near the shopping centres. The summary of results is given in Table 8.

The results from other localities connected to shopping centres are not as significant as those in the case of Olomouc. On the other hand, it can be stated that drivers are less attentive near shopping centres than in other localities. The share of traffic following is below average in 8 cases of 10. The higher probability of holding a cellular phone than on average is in 6 cases. Manipulation with vehicle control elements is over average in 3 cases only. Talking to others in vehicle is above average in 6 cases; working with paper documents in 4 cases. Higher rate of drinking+eating and smoking in 8 cases and dressing-up in 7 cases. The average values registered for the shopping centres also agree with this conclusion.

The particular conclusion to this topic is that drivers are less attentive when leaving shopping centres. The extended survey showed that this effect is less significant than in the specific case of Olomouc, but also the statistical hypothesis that leaving the shopping centre can decrease attentiveness on the general level cannot be rejected as well (with one exception in Brno).

City	Street	Vehicles	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking, eating, smoking	Dressing-up
Olomouc	Wittgensteinova	254	44.09%	9.06%	10.63%	23.23%	2.36%	10.63%	0.00%
Praha	Hráského	240	60.83%	5.00%	7.92%	7.08%	2.50%	7.92%	8.75%
(Prague)	Strakova	180	67.78%	5.56%	2.78%	13.89%	0.56%	6.11%	3.33%
	Ocelkova	240	67.50%	6.25%	2.50%	15.00%	0.00%	5.00%	3.75%
	Chlumecká	240	60.42%	8.33%	3.33%	15.42%	0.00%	9.58%	2.92%
	Bryksova	180	58.89%	8.33%	5.56%	12.22%	0.00%	12.22%	2.78%
	Řevnická /Ringhofferova	240	57.92%	10.42%	4.17%	14.58%	0.00%	9.58%	3.33%
	Řevnická /bus terminal	240	65.00%	8.33%	2.08%	15.42%	0.00%	5.42%	3.75%
Brno	Úzká	180	60.00%	13.33%	2.22%	13.89%	0.56%	7.78%	2.22%
	Opuštěná	180	60.00%	7.78%	2.78%	15.56%	0.00%	11.67%	2.22%
	All shopping centres	**2174**	59.98%	8.19%	4.55%	14.77%	0.64%	8.51%	3.36%
	All localities out of shopping centres	**14914**	65.84%	7.89%	4.18%	14.11%	0.48%	5.22%	2.29%
	All streets in the survey	**17088**	65.09%	7.92%	4.23%	14.20%	0.50%	5.64%	2.42%

Table 8. Activities of drivers at localities close to shopping centres. Source: Authors

Streets	Number of streets	Vehicles	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking, eating, smoking	Dressing-up
with trams	30	7533	64.26%	7.59%	4.67%	15.39%	0.54%	5.30%	2.24%
without trams junction with	15	3614	62.45%	9.13%	3.87%	15.80%	0.58%	4.90%	3.27%
without trams junction without (no trams at all)	13	3767	72.23%	7.27%	3.50%	9.95%	0.24%	5.36%	1.43%

Table 9. Activities of drivers at junctions according to tram operation. Source: Authors

Street	Operation of trams	Vehicles	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking, eating, smoking	Dressing-up
M. Horákové	reduced	180	70.56%	5.56%	9.44%	8.89%	0.56%	2.78%	2.22%
V Botanice	full	240	68.33%	8.33%	5.42%	10.83%	1.67%	5.00%	0.42%

Table 10. Activities of drivers at junctions according to extent of tram operation. Source: Authors

5.6 Impact of tram transport

The operation of trams at road junctions is considered as a complication by some drivers, especially those who are not used to driving in cities with trams. Trams are operated on 30 of the surveyed streets; 15 of the surveyed streets without trams are connected to a street with trams (in crossing direction at a junction) and 13 of the surveyed streets are connected to junctions without any tram operation. Streets in the surroundings of shopping centres with specific behaviour of drivers (see Section 5.5) are excluded. Therefore, comparison is possible.

The results from Table 9 lead to the omission of the mentioned hypothesis. The results show quite the opposite fact. Drivers are more attentive at junctions without any tram operation (they follow traffic in 72.23% of cases).

The Statistical χ^2 Goodness-of-Fit test leads to the conclusion that there is a statistically significant difference between the streets with and without tram transport.

To consider the possibility of assessing the impact of tram transport in full, one more point of view was applied. An important feature of tram traffic is also the ability to extend the time of red light at traffic lights. 2 surveyed streets from Prague were selected for this comparison.

The first street is Milady Horákové, where tram operation was reduced (but not fully stopped) during the survey. It was due to construction works on the tram infrastructure (tracks). The second street (to be compared) is called V Botanice. The vehicle flow was fluid there. Trams are preferred by signalisation; it means extension of red light for cars in the case that tram is coming. Queue of ca. 18 cars in average occurred in the case that trams of both directions met in this locality (on Štefánikova Street crossing the surveyed street – V Botanice).

The Table 10 leads to an idea that shorter red time discourages drivers from performing activities needing longer time (like making a phone call, talking to others, working with paper documents, etc.). Due to the fact that length of red-light time was not measured, this is presented for information only.

5.7 Qualitative and subjective insights

Qualitative aspects were surveyed subjectively only according to the estimation of the surveyors (people realizing the survey). For that reason, these results are not generalised. On the other hand, there are some insights, suitable to be pointed out in a few following paragraphs.

Drivers are more open to other activities than following traffic when the red-light time is invited to be longer. This was measured subjectively only. It is because the fact that the most of surveyed junctions work in dynamic regime (including preference of public transport means) and this length vary from ca. 30 s to 60 s.

Holding of cellular phone in the hands is more frequent in driving alone.

Drivers standing behind in a queue of cars sometimes use sound signal when the drivers in front of them react on the signal switch (start drive) with delay.

The features of surroundings of a vehicle are also important for the selection of the activity performed. Waiting drivers observe other vehicles; cyclists; or some specific situations (e.g. crossing of the street by apparently intoxicated persons with specific appearance and behaviour).

Some drivers also tend to think or fantasise when they stop. It is hard to recognise. Practically some drivers react on the switch of signal aspect with delay despite being classified as 'drivers following traffic'.

Stopping of talking in vehicles after signal switch was surveyed especially in the city of Frýdek-Místek, but it can be stated in general that passengers are open to follow traffic and adjust the way of communication according to the traffic situation.

It was registered that drivers inviting that time of waiting should be longer (standing on the first positions in front of traffic lights) are more open to perform activities like (phone, drinking, smoking, dressing-up) than drivers on the end of a queue.

6. STATED AND REVEALED PREFERENCES

An anonymous quick internet survey for comparison of stated and revealed preferences in this field was conducted by the students of the Palacký University Olomouc (within their internship at the University of Pardubice) in April 2022. There were 106 respondents in the survey with an average age of 25.3 years. The median age is 23 years and the mode age 22 years. This structure corresponds to the fact that the survey was initiated in a university environment. Due to the this and due to limited number of participants, the results are on an informative character only. The part of the 78.3% of respondents indicated that they often drive through traffic lights; 17.0% of drivers drive there a little and 4.7% rarely.

The results – stated preferences - are in Table 11. It is necessary to mention the main difference. All respondents evaluated all alternatives individually. For that reason, stated preferences express willingness to perform such activity, not the frequency expressed by terrain surveys in practise. This must be followed by an evaluation of the results.

Table 14 shows three important messages. The structure of stated preferences is similar to the structure of preferences revealed in practise.

Respondents are seen to overestimate following traffic felt as a required alternative. There is a logical underestimation of holding a cellular phone in hand because it is felt as unacceptable. On the other hand. 34% of the respondents indicated that they are open to accepting the use of a cellular phone while waiting at traffic lights.

There are high values in the case of talking to others in the vehicle. It must be noted that this activity is sometimes impossible in practise when the driver is alone in the vehicle. This is not considered in evaluation of surveys in practise. A similar effect is visible also when working with paper documents. Drivers should be open to using them (73.6%), but the need to use such paper documents decreases.

There is also an impact of the number of traffic lights (signalised junctions). It may be that being open to manipulation with vehicle control elements does not mean that this activity is performed at all passed junctions. Finally, general perception of individual alternatives plays a role as well.

The Internet survey did not focus on the activity group 'dressing-up'. This activity was added later as feedback from pilot surveys in the terrain.

7. SUGGESTIONS

This chapter should illustrate the framework for what is needed to deal with this issue and with the surveyed data. The suggestions are presented in a brief form as initial ideas only. The aim of the paper is to define activities performed by car (vehicle) drivers while waiting at traffic lights and not to bring proposals of complex solutions.

The suggestions are based on the fact that some of the activities that can decrease the attention of the drivers cannot be fully replaced. The activities are still too frequent.

7.1 Vehicle ergonomics

It is necessary to continue to research the ergonomics of vehicle components. It is seen that 4% of drivers manipulate with vehicle control elements, navigation, or radio devices or make a phone call using hand-free while waiting at traffic lights. It is necessary to keep control of the vehicle as well as all other vehicle systems simple. Manipulation with them should be clear, easy, intuitive, and comfortable to minimise manipulation time and increase driver attention.

Hands-free systems, as well as systems for connecting a cellular phone with a vehicle are known, but the share of drivers taking the cellular phone in their hands is still significant. So, this could be a possible way to expand these systems and contribute to the attentiveness of drivers. A threat should be application of more complicated ways of control (more complicated devices). The increasing number of manipulations (related to rising number of functions of such systems) as well as the increased manipulation time can decrease the attentiveness of the driver, both in the time point of view and in the point of view of the number of obligations (cases when it is necessary to manipulate with vehicle control elements).

Last, but not least, the feature is that an adequate ergonomic design of the vehicle cabin can help to reduce possi-

Survey	Willingness to perform the activity	Following traffic	Cellular phone	Control elements	Talking to others in vehicle	Paper documents	Drinking. eating. smoking	Dressing-up
Internet	Always	34.90%	1.90%	8.50%	29.20%	8.70%	6.60%	N/A
	Often	48.10%	1.90%	21.70%	44.30%	7.80%	13.20%	N/A
	Rarely	11.30%	8.50%	38.70%	22.60%	12.60%	20.80%	N/A
	Exceptionally	2.85%	21.70%	14.20%	1.95%	27.20%	33.00%	N/A
	Never	2.85%	66.00%	17.00%	1.95%	43.70%	26.40%	N/A
	Always+Often	83.00%	3.80%	30.20%	73.50%	16.50%	19.80%	N/A
Terrain	Frequency	65.09%	7.92%	4.23%	14.20%	0.50%	5.64%	2.42%

Table 11. Stated preferences to activities. Source: students of the Palacký University Olomouc

ble negative impacts of all activities – e.g., also by drinking, working with paper documents, etc. For example, clip to hold paper should make the manipulation with them more simple and safer when it is in a useful location.

The ergonomics issue is a specific research task and should be solved in a more complex way. The objective of this suggestion is to point out the relation between ergonomics and attentiveness at traffic lights.

7.2 Short-time parking places at rush roads in major cities

The second (and may be more important) suggestion is for transport planners and road designers. The core of suggestion is to create short-time parking places (spaces) at suitable places on main roads in major cities.

It can be a similar system to the Kiss and Ride (K+R) parking known from public transport terminals. The K+R parking places allow quick boarding or alighting of public transport passengers close to the public transport platforms.

Suggested parking places will allow driver to make a short break in drive, to serve needs of children, to manage a phone call, to set modified route in navigation system, etc. In general, it can be a place where potential risky activities can be allocated. No driver will be allowed to leave a vehicle. Such places must be able to be simply reached by driver. There is no effort to create as robust a parking system as possible. The prior function of this system should be positive motivation for drivers to make safer decisions.

This suggestion also reacts to the fact that the possibilities to stop a vehicle are reduced in city areas. So, the basic traffic principle, stopping the vehicle when needed, is very limited today due to always full parking places or lack of parking possibilities on main streets of the city.

8. DISCUSSION AND FUTURE RESEARCH

The survey presented and the paper show what car drivers do in vehicles while waiting at traffic lights in city areas in the Czech Republic.

Most of the drivers surveyed (65%) observe and follow the traffic situation and remain attentive. The second group of activities is talking to others in a vehicle with a share of 14%. This is very positive. Both these activities belong to safe activities, despite they also have some negatives (e.g. solution of complicated topics by talking, etc.).

Manipulation with vehicle control elements could be classified as neutral activity (it needs attention, but usually for a short time). The share of this activity is 4%. The issue related to this activity can be that the frequency of this activity should increase. It can be related to the increasing volume of possibilities provided by vehicle communication, information, navigation, and control systems.

The problem is that 8% of drivers hold a cellular phone in hand and 1% of drivers work with paper documents or manipulate with a handbag.

Drinking, eating, and smoking are performed by 6% of drivers and dressing-up by 2% of them. Most of these activities belong to physiological ones. Both suggestions presented in this paper follow the above-mentioned facts. Adequate ergonomics of vehicles and interface of vehicle communication, information, navigation, and control systems can reduce time needed to manipulate them. It can for the compensate also rising volume of these manipulations.

Suggestions also follow the fact that it will be difficult to replace these activities. This is due to their relative significant frequency (activities capable of decreasing attention in a significant way occurred in 21% of surveyed vehicles). Their importance for drivers can also be visible in the results of the on-line survey of stated preferences. More than 15% of the respondents are open to these activities, with the exception of holding a cellular phone in their hands. It may be that moral disapproval of cellular phones by drivers has an impact on this criterion (3.80% respondents stated that they are open to use the phone). The value of practise (8%) shows greater significance.

Potential future work should focus on a deeper analysis in such perspective directions followed within this research. Activities in leaving residential areas should be surveyed in more localities and streets to collect more relevant data. Fluctuations in willingness to perform these activities depending on a time of day can be also a similar possibility how to extent the research.

The next line of future research should be the comparison of large cities with smaller cities and municipalities. In other words, how the share of surveyed activities will change when drivers know that they will leave the municipal (city) area in a short time of if they have there more possibilities where to park a vehicle, etc. The organization of a survey of stated preferences in a more extended way should also be a possibility how to expand this research. The potentially important research issue could be searching for the relation between performed activities and the length of red light together with the anticipated length of red-light.

Another potential way of future research can be deep analysis of behavior of drivers by application of specific technical equipment monitoring them while driving. Design of such research should be quite different – lower number of drivers, monitoring of driving not only at signalized junctions etc., but it is a possibility.

Research of relations, how resulting traffic situation at junction can be influenced by performed activity while waiting in front of traffic lights, can be next way, how to extent the research. Such research should be limited to lower number of junctions and video surveying should be added.

9. CONCLUSION

The paper deals with activities performed by vehicle (car) drivers waiting at traffic lights in the city area in the conditions of the Czech Republic. Such of these activities could be a potential risk factor for traffic accidents.

The main conclusion is that 79% of drivers perform activities with relatively small impact on safety. They are still concerned about traffic situation, or they talk to other passengers in the vehicle. Remining activities are performed by 21% of drivers. These activities should reduce attention and should cause a delayed start of the drive after the switch of the traffic light signal. There are also incorporated 4% drivers manipulating with car control elements even though this activity is considered as neutral from the safety point of view (it is sometimes necessary to be done). Risky activities (drinking+eating+smoking; dressing-up; paper documents and especially holding a cellular phone in hands) are registered by 17% of drivers. The total volume of vehicles surveyed is 17,088. Making these activities easier to reduce their impact on driver attention and designing parking spaces for short stops on city streets are mentioned as suggestions for improving transport safety. This paper creates a base – defines groups of performed activities, their frequency, and provides basic evaluation according to effects connected to locality (e.g., direction of drive, distance from city centre, way from shopping centre). The research has potential to be more detailed and extended. Some of these possibilities are mentioned in the chapter 8.

ACKNOWLEDGEMENTS

Special thanks belong to the team of students from the University Palacký Olomouc for performing the survey and for participating in survey organisation.

Namely (Surname and Name): Beránková Jana, Dusílková Jana, Groulíková Lenka, Honzíková Karolína, Komůrková Veronika, Košťálová Pavlína, Lancová Denisa, Meisnerová Dorotea, Mikolášová Marie, Nováková Dorota, Peřinová Adéla, Piknová Celestýna, Pospíšilová Kateřina, Skalická Kateřina, Šťastná Kristýna, Štenclová Eliška and Zítová Olga. Names are mentioned in alphabetical order.

All participants were informed about the naming in the paper in advance, and no one expressed disagreement.

STATEMENTS

AI-assisted technologies: During the preparation of this work, the authors used Google Translator in order to translate some words or individual sentences, and Writefull in order to check English grammar. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

The research funding is institutional from the budgets of the University of Pardubice and the Palacký University Olomouc (organisation and support of internships of students).

AUTHOR CONTRIBUTIONS EXPRESSED BY CREDIT ROLES

Bulíček, J. – Methodology; Conceptualization; Investigation; Writing-original draft
Drdla, P. – Formal analysis; Investigation; Validation; Project administration; Writing-original draft
Students of the Palacký university Olomouc – Investigation

REFERENCES

Beneš, J., & Ledvinová, M. (2014). Využití modelování pro návrh organizace dopravy na křižovatce řízené SZZ v Litomyšli (in Czech). Application of Modelling for Proposal of Traffic Organisation at Junction controlled by traffic lights in the city of Litomyšl. *Perner's Contacts*, 9(3), 6–18. https://pernerscontacts.upce.cz/index.php/perner/article/view/641

Bouchner, P., Novotný, S., Radová, Z., & Válek, J. (2016): Metodika měření vizuálního pole řidičů s přirozeným omezením (in Czech: Methodology for measurement of visual filed of drivers with natural limitation). *Certified methodology.* Praha: ČVUT, 2016, 34 p. https://www.mdcr.cz/Dokumenty/Veda-a-vyzkum/Certifikovane-metodiky/Silnicni-metodiky/Metodika-mereni-vizualniho-pole-ridicu-s-prirozeny

Chen, M., Nyazika, S., & Singhal, A. (2016). Effects of a front-seat passenger on driver attention: An electropsychological approach. *Transportation Research Part F: Traffic Psychology and Behaviour, Vol. 43,* p. 67-79. https://doi.org/10.1016/j.trf.2016.09.016

Felicio, G. P., Grepo, L. C., Reyes, W. F., & Yupingkun, L. C. (2015): Traffic Light Displays and Driver Behaviors: A Case Study. *Procedia Manufacturing, Vol. 3,* p. 3266-3273. https://doi.org/10.1016/j.promfg.2015.07.879

Gherman, C. M. (2012): Maslow Pyramid – Possible Interpretation. *International Journal of Learning & Development, Vol. 2, No. 1,* ISSN 2164-4063. http://dx.doi.org/10.5296/ijld.v2i1.1520

He, Y.-L., Li, R.-T., Li, L., Schwebel, D. C., Huang, H.-L., Yin, Q.-Y., & Hu, G.-Q. (2019): Left-turning vehicle-pedestrian conflicts at signalized intersections with traffic lights: Benefit or harm? A two-stage study. *Chinese Journal of Traumatology, Vol. 22,* Issue 2, p. 63-68. https://doi.org/10.1016/j.cjtee.2018.07.007

Huth, V., Sanchez, Y., & Brusque, C. (2015): Drivers' phone use at red traffic lights: A roadside observation study comparing calls and visual–manual interactions. *Accident Analysis & Prevention, Vol. 74,* p. 42-48, https://doi.org/10.1016/j.aap.2014.10.008

Jame, A., Rapelli, M., & Casetti, C. (2022): Reducing pollutant emissions through Virtual Traffic Lights. *Computer Communications, Vol. 188,* p. 167-177, https://doi.org/10.1016/j.comcom.2022.03.018

Kleprlík, J., & Matuška, J. (2017): The demand for public transport and modelling decision-making process of passengers. 21st International Scientific Conference Transoport Means 2017, Part 1, 197-202, ISSN 2351-7034. https://www.dropbox.com/sh/7sjhe2ln3e3qin6/AABBl1Gbrf0_t8lM7Kho8KmVa?dl=0

Kovačič, B., Doler, D., & Sever, D. (2021): Innovative Business Mode for the Management of Airports in Purpose to Identify Runway Damage in Time. *Sustainability 2021,* 13(2), 613; https://doi.org/10.3390/su13020613

Laurier. E. (2001): *Notes on dividing the attention of a car driver.* LSCITS: STSE-Handbook. https://archive.cs.st-andrews.ac.uk/STSE-Handbook/Other/Team%20Ethno/Issue1/Laurier/gooddriv.html

Małecki, K., & Iwan, S. (2019): Modelling traffic flow on two-lane roads with traffic lights and countdown timer. *Transportation Research Procedia, 39 (2019),* p. 300-308. https://doi.org/10.1016/j.trpro.2019.06.032.

Mapy.cz (2023) – map server. Seznam.cz, a.s. and others, 2023. www.mapy.cz

Palat, B., & Delhomme, P. (2016): A simulator study of factors influencing drivers' behavior at traffic lights. *Transportation Research Part F: Traffic Psychology and Behaviour, Vol. 37,* p. 107-118. https://doi.org/10.1016/j.trf.2015.11.009

Radivojević, M., Tanasković, M., & Stević, Z. (2021): The adaptive algorithm of four way intersection regulated by traffic lights with four phases within a cycle. *Expert Systems with Applications, Vol. 166,* 2021, 114073. https://doi.org/10.1016/j.eswa.2020.114073

Ramirez-Polo, L., Jimenez-Barros, M. A., Narváez, V. V., & Daza, P. D. (2022): Simulation and Optimization of Traffic Lights For Vehicles Flow in High Traffic Areas. *Procedia Computer Science, Vol. 198,* p. 548-553. https://doi.org/10.1016/j.procs.2021.12.284

Salvia, E., Petit, C., Champely, S., Chomette, R., Di Rienzo, F., & Collet. Ch. (2016): Effects of Age and Task Load on Drivers' Response Accuracy and Reaction Time When Responding to Traffic Lights. *Frontiers in Aging Neuroscience. Sec. Neurocognitive Aging and Behavior, Vol. 8 – 2016.* https://doi.org/10.3389/fnagi.2016.00169

Scandella, M., Ghosh, A., Bin, M., & Parisni, T. (2022): Traffic-light control in urban environment exploiting drivers' reaction to the expected red lights duration. *Transportation Research Part C: Emerging Technologies, Vol. 145,* 103910. https://doi.org/10.1016/j.trc.2022.103910

Seifert, Z. (2009): Příbramské křižovatky (in Czech: Junctions of Příbram). Příbramský deník, 2009. https://pribramsky.denik.cz/zpravy_region/krizovatky20090625.html

Široký, J., & Hlavsová, P. (2018): Optimizing process of check-in and security check at airport terminals. *MATEC Web of Conferences 236,* 01003 (2018). https://doi.org/10.1051/matecconf/201823601003

Yang, B., Wang, Z., & Nakano, K. (2022): Effects of penetration rates on the application of in-vehicle traffic lights at unsignalized intersections. *Traffic Injury Prevention, Vol. 23, Issue 5,* p. 260-265. https://doi.org/10.1080/15389588.2022.2052285