POSTER SESSION

EVALUATION OF A SURROGATE FORWARD COLLISION WARNING SYSTEM IN AN ELECTROPHYSIOLOGICAL PERSPECTIVE

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ABSTRACT: Driver distraction has been identified as the most important contributing factor in rear-end collisions. In this context, Forward Collision Warning Systems (FCWS) have been developed specifically to warn drivers of potential rear-end collisions. The main objective of this work is to evaluate the impact of a surrogate FCWS and of its reliability according to the driver's attentional state by recording both behavioural and electrophysiological data. Participants drove following a lead motorcycle in a simplified simulator with a warning system when they were undistracted or distracted by a cognitive secondary task. Behavioural and electrophysiological data contributed to revealing a positive effect of the warning system. Performance and information processing at neural level were considerably affected by the secondary task; however the warning system seems to reduce the negative impact of the dual task. Nevrtheless this effect seems due to a facilitation of the processing in simple task rather than a facilitation in dual task. Electrophysiological data could be a valuable tool to complement behavioural data and to gain a better understanding of how these systems impact the driver.

1. INTRODUCTION

Rear-end collisions represent about 30% of all car crashes and involve an important economic cost for society [1]. Driver inattention has been identified as the most important contributing factor in these collisions [2]. In this context, Forward Collision Warning Systems (FCWS) have emerged to warn drivers of potential rear-end collisions. It has been expected that these systems are of benefit to distracted drivers; however, most of the studies showing an advantage of these systems were conducted with undistracted drivers (e.g. [3, 4]).

FCWS are effective tools; nevertheless, they are not completely reliable, and differences in acceptance and on driver performance could be noticed depending on the missed or false alarm rate given by the system [5].

Therefore, the main objective of this work is to evaluate the impact of a surrogate FCWS on drivers according to both the attentional state of the drivers and the reliability of the system.

To this end, behavioural and electrophysiological measures have been recorded in a simplified simulator. The electroencephalography (EEG) and the associated event related potential (ERP) technique enable the distinction between the different stages of the information processing such as the sensory visual processes identified by the visual N1 component and the higher cognitive processes identified by the N2 and P3 components (for a review see [6]).

2. METHOD

2.1. Participants

12 right-handed men (mean: 30.6) took part in this experiment. They had held a driving license for at least four years and declared that they drove at least 3000 km per year. Participants were financially compensated for their participation.

2.2. Stimuli and procedure

Participants were required to drive a simplified simulator following a lead motorcycle. From 6 to 12 s, the motorcycle decelerated and participants had to remove their foot from the accelerator pedal as fast as possible only in response to the brake light (visual target) of the motorcycle. An auditory warning system could be presented from 1.5 to 2.3 s before the target to forewarn participants. Three warning conditions were defined: *no system*, the visual target was never preceded by the warning; *imperfect system*, the visual target was preceded by the warning in 70% of the trials, the warning was presented alone in 15% of the trials (false alarm) and the visual target was not preceded by the warning in 15% of the trials (miss); and *perfect system*, the visual target was always preceded by the warning.

Participants had to perform the visual detection task either alone (simple task, ST) or with a secondary cognitive task (dual task, DT). In the secondary task, a set of three words with apparently no links between them was given orally to the participants who had to find a fourth word linked to each of the three words. This association could correspond to a semantic link, an expression, a compound word or a synonym.

2.3. Data acquisition and data analysis

Behavioural data analyzed was the corrected mean reaction time (RT) to the target stimuli.

The electrophysiological data were recorded using Biosemi ActiveTwo system from 34 active electrodes distributed over the scalp according to the International 10-20 System. The ERP epochs for the N1, N2, and P3 began 100 ms before the target stimulus and lasted 600 ms after this stimulus. The data were baselined to the pre-stimulus activity and digitally band-pass filtered down 60 dB at 0.2Hz and 30Hz. Trials with artifacts such as muscle activity, skin potentials or eye movements were removed before averaging ERPs for each condition.

The peak amplitude and the latency of the peak of the visual N1 component were detected on a time window from 150 to 275 ms and on electrode sites P7, P8, O1, O2, Ima, Imb. The amplitude and latency of the N2 component were detected on electrode sites Cz, FC1, FC2 from 150 to 275 ms; and the amplitude and latency of the P3 were detected from 250 to 500 ms on P3, Pz, P4, PO3, PO4, CP1, CP2.

Both behavioural and electrophysiological measures were submitted to a two-way repeated measures analysis of variance (ANOVA) with the distraction level and the warning conditions as factors.

3. RESULTS

3.1. Behavioural results

Accelerator release reaction times for distraction level and warning conditions are presented in Figure 1. There was a main effect of distraction level ($F(1,11)=20.68$, $p=.001$). The main effect of warning conditions was not significant ($F(2,22)=2.85$, $p=.079$) and there were no interaction effects ($F(2,22)=1.03$, $p=.372$).

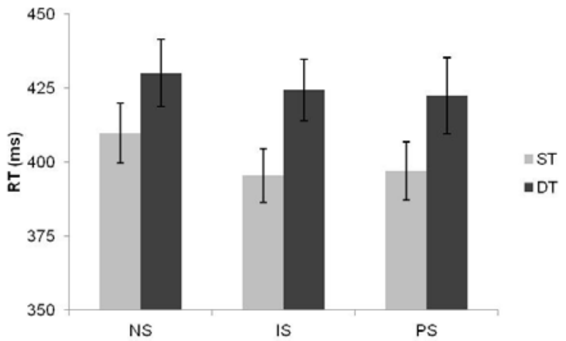

Fig 1. Reaction times (RT) and standard error for No System (NS), Imperfect System (IS), and Perfect System (PS) conditions in Simple Task (ST) and in Dual Task (DT).

The analysis of the simple effects for the distraction level condition revealed faster RTs when participants were undistracted than when they were distracted in the three system conditions: no system ($F(1,11)=17.49$, $p=.002$), imperfect system ($F(1,11)=13.54$, $p=.004$), and perfect system ($F(1,11)=14.72$, $p=.003$). Despite the main effect of warning conditions not reaching statistical significance ($p=.079$), further separate analyses showed that participants reacted faster when they were undistracted and warned by a perfect ($F(1,11)=5.71$, $p=.036$) or an imperfect system ($F(1,11)=7.32$, $p=.020$) than when they were not warned at all. No significant differences were found among the warning conditions when participants were distracted.

3.2. ERPs results

3.2.1. Impact of the distraction level (Simple Task, ST; Dual Task, DT)

The maximum amplitude of the N1 was significantly reduced in the DT condition compared to ST only when no system was presented, ($F(1,11)=9.06$, $p=.012$) (Figure 2a). Regarding the N2 component, its maximum amplitude was reduced in DT compared to ST for no system ($F(1,11)=23.70$, $p=.0005$) and also for the perfect system ($F(1,11)=8.93$, $p=.012$) (Figure 2b). In addition, the DT significantly reduced the maximum amplitude of the P3 component when there was no system ($F(1,11)=14.33$, $p=.003$) and when an imperfect system was presented ($F(1,11)=11.77$, $p=.006$) (Figure 2c).

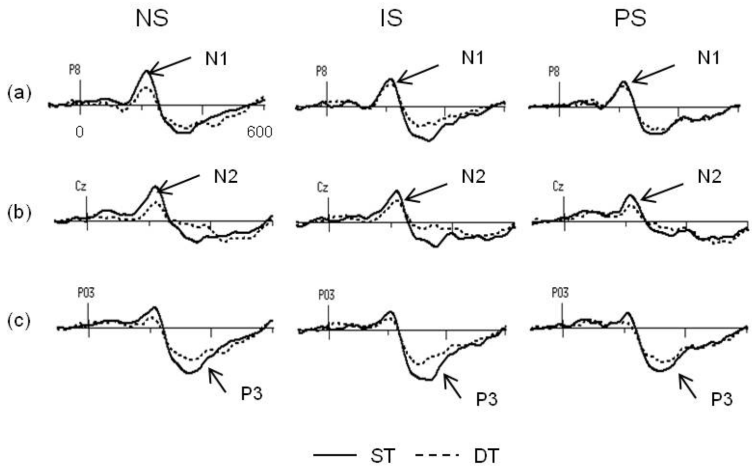

Fig 2. Grand average of the ERP showing (a) the N1 at P8, (b) the N2 at Cz, and (c) the P3 at PO3 in ST and DT for no system (NS), imperfect system (IS), and perfect system (PS) conditions.

Finally, it is worth noting that the difference between ST and DT was less noticeable in the perfect or imperfect system condition than in the no warning condition.

3.2.2. Impact of the warning conditions (No System, NS; Imperfect System, IS; Perfect System, PS)

The impact of the warning condition according to its reliability was analysed separately in ST and DT (Table 1).

Table 1. Amplitude (μV) and latency data (ms) of the N1, N2, and P3 in the ANOVA with warning conditions (No System, NS; Imperfect System, IS; Perfect System, PS) as factor in ST.

		N1 (P8)		N2 (Cz)		P3 (PO3)		N2-P3 (CP1)	
		ST	DT	ST	DT	ST	DT	ST	DT
Amplitude	NS	-9.83	-7.27	**-9.15**	-5.53	11.71	8.92	**16.95**	11.48
	PS	-8.76	-7.15	**-7.46**	**-5.01**	10.97	9.56	**14.85**	11.42
	IS	-9.08	-7.98	-8.47	**-6.41**	12.68	9.25	**17.49**	12.6
Latency	NS	213	207	**214**	215	343	**364**	-	-
	PS	209	211	**207**	205	325	325	-	-
	IS	214	213	**212**	205	335	**337**	-	-

* *p*<.05
** *p*<.01

In ST condition, no significant differences were found in amplitude (F(1,11)=0.83, p=.44) and latency (F(1,11)=0.88, p=.42) of the N1 component among the three warning conditions. The presence of the PS significantly reduced the peak amplitude (F(1,11)=7.02, p=.023) and latency (F(1,11)=13.70, p=.003) of the N2 component compared to NS. In the same way, the latency of the N2 was reduced by the presence of the PS compared to the IS (F(1,11)=6.09, p=.031). The latency of the P3 component was reduced by the PS compared to NS; however this difference was marginally significant (F(1,11)=4.78, p=.051).

Regarding the DT condition, no significant differences were found among the three warning conditions for the N1 component in amplitude or latency. With regards to the N2 component, its maximum amplitude was significantly decreased by the presence of the PS compared to the IS (F(1,11)=10.13, p=.008). For the P3 component, no differences were found between the presence and the absence of the system. Only the difference between IS and NS was statistically significant (F(1,11)=8.04, p=.016), showing a reduced latency in the IS compared to the NS.

4. DISCUSSION

The results of this study showed slower reaction times when participants were distracted. This suggests that the secondary task diverted attention away from the road. In addition, at the neural level, the processing of the target was also disrupted by performing the secondary task: the amplitude of N1, N2 and P3 was considerably reduced when participants were distracted. This could reflect a diminution of the attentional resources allocated to the target [7].

Concerning the reliability of the warning, participants were faster in detecting the target when the system was both perfect and imperfect; however, this effect was not evident when participants were distracted. In addition, the ERP curves showed weaker differences between undistracted and distracted participants when the warning system was available. This result seems at least partially due to a facilitation effect of the warning when participants were undistracted rather than when drivers were distracted. This facilitation effect confirmed by the RT, might be related to temporal expectancy [8] as well as a modulation to the cognitive control (monitoring or regulation of strategy) [9] improved by the warning. These processes were reflected by a decrease of the amplitude of the three components when the warning was presented but only in undistracted participants.

The warning ineffectiveness when drivers were distracted could be explained by the presence of another predictor of the target besides the warning: the deceleration of the motorcycle before the brake light. Therefore, participants could have prioritized this visual information over the warning signal as the main predictive information for anticipanting the target. Finally, it could be also possible that participants could have not enough attentional resources available to process the warning given the difficulty of the secondary task. Therefore, further research shoud be necessary in this innovative field before to be able to generalize these results.

5. ACKNOWLEDGMENTS

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ROUTE OPTIMIZATION SYSTEM FOR ROAD EMERGENCY SERVICES

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ABSTRACT: Emergency teams are a quite special group of road users; their main aim is to reach the incident scenario as quickly as possible to try to minimize the damage caused by the incident. The system proposed in this article consists of an Emergency Route Management Service for emergency teams that offer the optimal route to get the incident; making use of dynamic elements road registry such as central reservation localization and factors unavailable to other solutions (real time local traffic information, highway operator related incidents due to maintenance works, etc.). This additional information is collected by means of advanced sensorization systems deployed along the transport infrastructure, thanks to the communication capabilities offered by Cooperative Systems nowadays.

1. INTRODUCTION

Nowadays, it is estimated that, every year, as many as 43,000 people are killed and nearly 1.7 million injured as a result of road accidents. One of the major problems when an accident occurs is the high probability of secondary collisions as it is explained in [1]. Therefore, it is of vital importance that the accident is solved completely, including restoration issues in the area, in the shortest time possible to increase the safety of both drivers and passengers involved in the accident and the reminder of users of the road.

Projects carried out in the Intelligent Transport Systems' field, usually rely on an infrastructure which monitors enhanced information about the road as well as incidents, density of vehicles, etc. in order to improve the mobility of the vehicles and enable a safer driving to users. Some projects have contributed to efficient traffic management, dealing for instance with the alerts associated to incidents or with information about the traffic status in order to provide guided routes services (COOPERS [2] and CVIS [3]); other, have focused their research activities on the detection of potentially hazardous situations (SAFESPOT [4]), among others. On the other hand, some ongoing projects, such as Co-Cities [5] or Instant Mobility [6], use traffic data and the availability of public transport in order to provide custom trips in real time to the road users.

Therefore, the projects listed above are intended to manage or foresee incidents, so the traffic status will be improved. In addition, they provide optimal routes depending on possible events or incidents on via and taking into account information about critical traffic flows. The main objective of the proposed solution is to provide a specific group of road users with a custom route that uses information about special features of the road as the location of the central reservation or the hard shoulder characteristics. Additionally, apart from the information related to traffic flows and traffic jams, our tool also provides information of the type of incident that has caused these undesirable situations.

Emergency teams are a special group of road users. While their basic task is to give fast response to an incident, their related actuations are quite complex involving a number of strict and varied requirements. Their main goal is to reach the incident scenario as quickly as possible in order to minimize the damage caused by the incident, either in material or in personal terms, being necessary for this purpose that every part of the emergency response system must be tuned up for maximum efficiency.

One of these elements is, without any doubt, the choice of the optimal route to reach a given incident. The system proposed in this paper integrates an additional application into the existing emergency response management systems so that, amongst the information relayed to the emergency teams to attend any given incident, an optimal route to reach the incident scenario is included. This route incorporates dynamic road elements and factors unavailable to other solutions, such as real time local traffic status information, or highway operator registered incidents due to maintenance works, etc., thus resulting in a valuable intelligence which, added to the personal experience and knowledge of emergency teams in relation to the incident area, might help saving a critical amount of time when guiding these teams to any given incident.

The proposed system is an Emergency Route Management Service that makes use of two services implemented in different modules. The former provides, upon request, interesting information related to static characteristic and road traffic. The second module uses this data to calculate the best route to reach an emergency.

The organization of this paper is as follows: firstly, the two main modules of the proposed system are described; then, the global system and a selected use case are detailed and finally, the main conclusions extracted are explained.

2. EMERGENCY ACTIONS MANAGER

The Emergency Actions Manager (EAM) is a Web-based Service which controls the alerts generated and registered when any incident happen in the highway, following the theoretical indications of management explained in [1] and [8]. The application allows infrastructure devices, which can detect incidents automatically, and validated users (e.g. emergency response management services or road operators) to introduce new alerts. However, only validated user can modify the data of some alert, close or delete an incident, etc.

When the system has registered a new incident, it searches for data about the environment around. This kind of information is collected directly by the road infrastructure and road users, therefore providing accurate, first hand information about the incident environment and conditions. The information about the road in which the incident took place is stored into a database. This database is formed by a group of tables containing data about the road layout, the different lanes, the hard shoulder, the ditch, the central reservation, the shoulder, the signalling systems, the restrain systems and the signals in the location where the incident has occurred.

All these data are forwarded to the route service, so that, in a simple scenario example, the information of the geo-coded location of a given incident, together with the data about a central reservation in the vicinity, is used by the route service to calculate the optimal route to be sent to the emergency teams.

Additionally, the system can get information about weather conditions, visual information that allow emergency teams to know in advance the state of the implicated area to plan their actuation, the material needed, etc. This information is stored into another database different from the information about the road conditions.

Fig. 1. Emergency Actions Manager

Figure above shows how the infrastructure detects automatically a stopped car and a pedestrian in the shoulder of the road. The right side of the illustration is a capture of the Emergency Actions Manager application in which the incident is registered.

3. ROUTE SERVICE

In the proposed system, the Route Service aims to calculate the optimum route for reaching the emergency scene as soon as possible. In order to achieve the best route, our service uses the information about road incidents and the environment around registered by Emergency Actions Manager (road features, accidents, traffic jams, road works…).

Based on client/server architecture, communication is carried out by TCP sockets. Both entities exchange data via XML format to enable connection/disconnection to the service, route requests and routes themselves. Firstly, a client subscribed to the service (in this case, the EAM) sends a route request indicating the desired destination from a given origin, request which can be complemented with additional information, so that the communication can be established. When the request is received and processed by the application server, the calculation of the optimal route is carried out as follows:

- o The route service makes use of Google Maps API [9] to acquire (via Java Script) all the possible routes between the requested origin and destination.
- o When all these routes have been received in our server, the additional information about the incident provided by Emergency Actions Manager is taken into account to estimate the routes duration.
- o At the end, the optimal route to be sent to the corresponding user will be the one with the shortest estimated duration; all routes are monitored by the server (see Fig. 2, Fig.3).

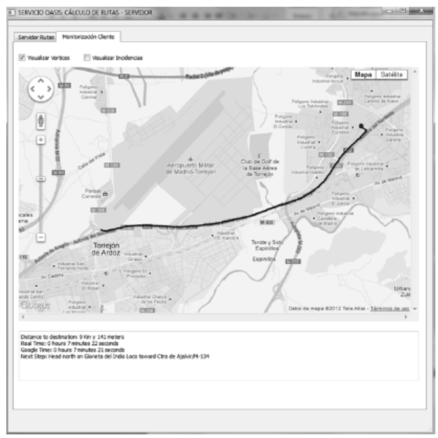

Fig. 2. RouteService (I) **Fig. 3. Route Service (II)**

4. EMERGENCY ROUTE MANAGEMENT SERVICE

The main objective of the system proposed in this paper is to calculate a more comprehensive traffic route for the emergency teams. It is based on the integration of the Emergency Actions Management service (EAM) with the Route Service (RS) described in the previous sections, along with additional information available. This additional information may enter the system through road advanced sensorisation infrastructure, advanced V2I communications, or other technological means.

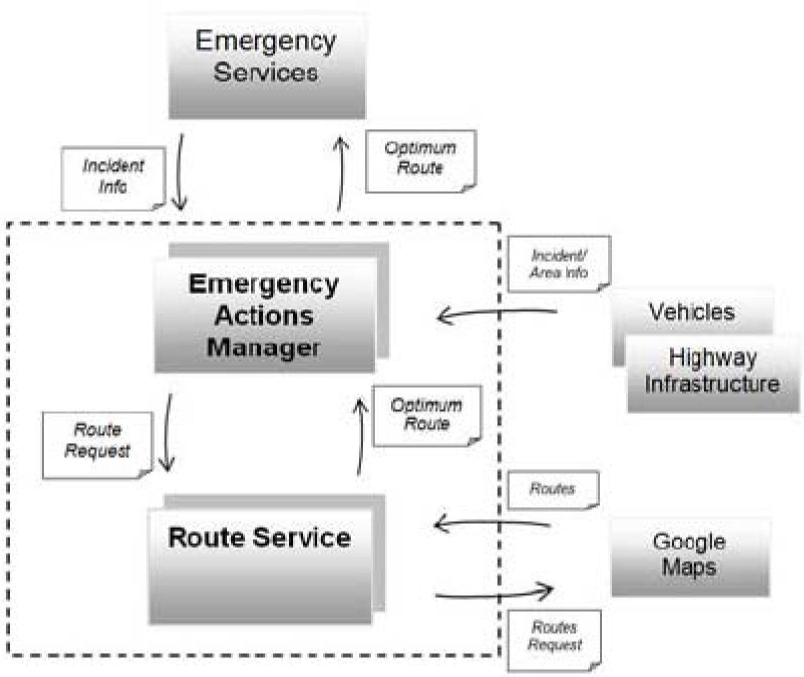

Fig. 4. Emergency Route Management Service

Fig. 4 describes the overall data flow of the proposed system. Firstly, the Emergency Route Management Service is notified by the Emergency Service and other possible actors, like infrastructure devices, about incidents that have taken place, including information about incident location, type, etc.

Once the EAM registers the present incident, it sends a special request for the associated route to the RS. In addition to the data from the EAM, the RS requests all possible routes to the Google Maps API; so, the optimal route is calculated from all the available information, including emergency road infrastructure features, traffic conditions, possible alternatives, etc.

In order to ensure the proposed system efficiency, it is essential to have a communication link between EAM and RS as simple as possible, requiring to exchange the minimum set of data possible so that the emergency teams may obtain the information with the minimum delay. In addition, the communication will be established through TCP sockets in order to allow the interoperability between different systems, regardless of their location or the platform that gives support to them.

Finally, optimal route is sent to the EAM and then forwarded to the corresponding emergency teams coordinated by the Emergency Services Management. Special care is taken so that the route guiding information relayed to the teams does not interfere with other tasks; therefore the proposed system uses a hybrid HMI with both a graphical route representation and a voiceassisted guiding interface with brief, precise indications.

5. USE CASE

The scenario represented in the attached figure, Fig. 5, intends to show the efficiency of the proposed system. As it can be seen, an emergency in M-12 road has occurred on the decreasing direction (point B); however, emergency teams are located in the opposite direction.

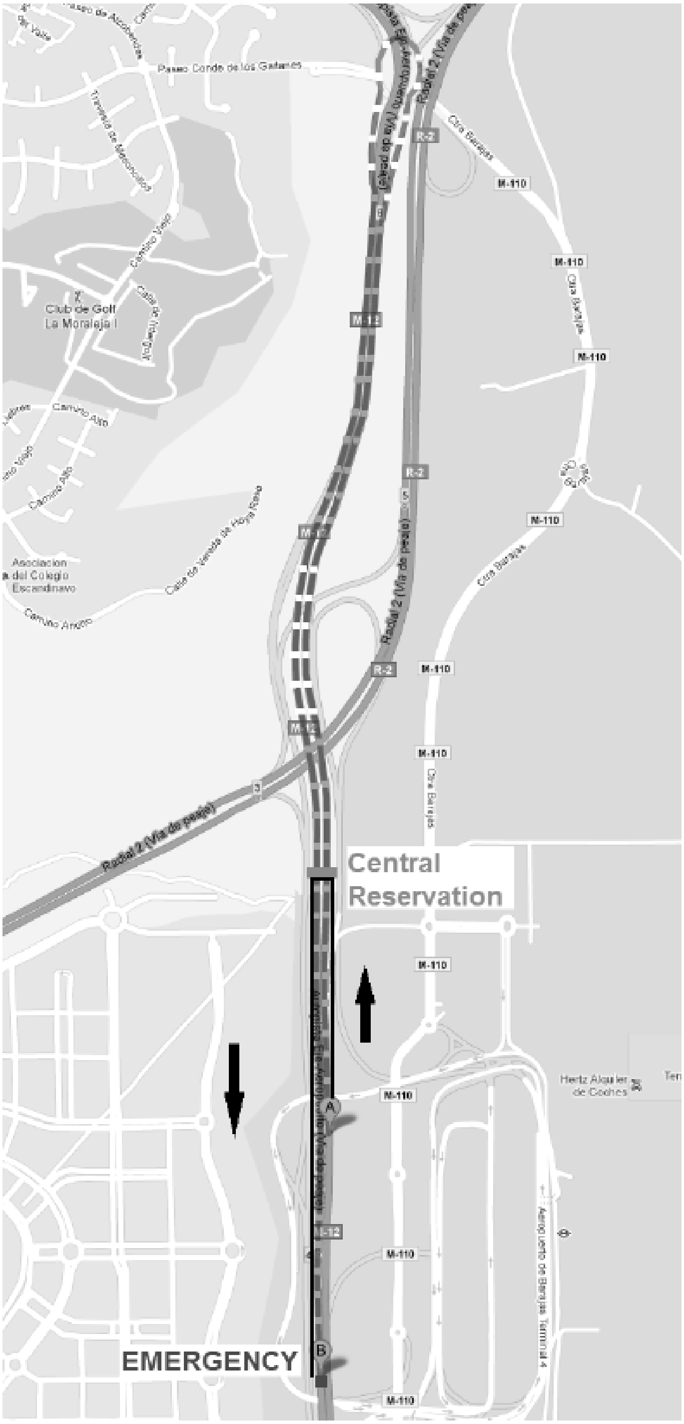

Fig. 5. Use Case Scenario

Optimal route calculation will start because of one of these cases: on the one hand, the infrastructure itself will detect an incident which will be registered in the EAM. These data will be available when the emergency teams ask for the optimal route depending on the information about the environment around. On the other hand, the emergency teams will notify the system about a new alert and will initialize the processes of data collection and calculation of the route.

In both cases, concentrating on this particular scenario, the initial route provided by the Route Service will be the discontinuous one, that links the origin point (A) to point (B), where incident occurs. However, in order to minimize the time to reach the incident, the EAM in our system provides RS with information about the existence of a central reservation, so it ideally recalculates the optimum route (black route in Fig. 5), including the central reservation as part of the final route.

6. CONCLUSIONS

In this paper, the proposed service responds to a given alert about a road incident, making use of cooperative technologies to gather all the information relevant to the location reference and environment around the incident. This information should be the most important, simple and, visual if it is feasible, to facilitate emergency teams work in order to restore the implicated area as soon as possible.

Our system makes use of an external map and a route provider to finally calculate an optimal route for the emergency teams to reach the incident in the least intrusive way to their driving tasks.

The two services that compose the proposed system have been implemented and tested individually. In addition, the communication by TCP sockets between these services and other external systems has been tested successfully. Because of this, it is expected that the integration of the two services will work properly, although it has not tested yet.

The Route Service measures the reliability of the routes that provides the server. Therefore, the improvement of the reliability and quality of the final proposed routes can be evaluated by comparing the results of the Route Service with the Emergency Actions Manager’s ones.

It is expected an increase of the quality and efficiency of the routes that our system provides, because information is collected directly by sensors which are installed on the road infrastructure and there are additional data available, belonging especially to the road’s characteristics, to obtain optimal route for the Emergency Services.

Optimal route calculation in connection with an effective management of incidents will provide enough information to emergency teams. Therefore, a service such as Emergency Route Management Service can improve the safety on the road network by decreasing the time it takes emergency teams to reach an accident and solve it. Some of the implied benefits that it entails are an improvement on injured users’ attention, a decrease in a number of secondary accidents and traffic jams that take place while the accident is being solved, etc. These benefits will have a positive impact on users regarding to roads and safety on them.

7. ACKNOWLEDGEMENTS

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TRAFFICCHECK.AT – A COOPERATIVE ONLINE-TOOL DEVELOPED BY USER INNOVATION TO EVALUATE TRAFFIC LIGHT SIGNAL REGULATED INTERSECTIONS

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ABSTRACT: TrafficCheck.at is an online-tool for different road user groups to evaluate traffic light signal regulated intersections (TLSRIs). Starting point is the concept of urban sensing where data about urban areas are collected through the involvement of citizens using information technologies. In focus groups the different needs of various road user groups were collected. Therefore seniors and persons with restricted mobility are stressed by too short green phases, have problems in identifying the traffic light or with barriers like too high pavements while parking cars in the vicinity of road crossing the visibility of bikers reduce or pedestrians fear they are overlooked by right turning cars just to mention a few of the results. Based on these results experts of different areas discussed the important criteria of the tool at a workshop. One of the essential requirements for the administration is the differentiation of the message they are receiving - whether it is about a defect or a quality evaluation of the TLSRI. The user oriented needs and the expert opinions contributed to the quality evaluation scheme of the system. TrafficCheck.at is currently programmed as prototype for Graz. The online-tool is a new approach to integrate the users` points of views into a modern system of quality management for traffic light systems.

1. STARTING POINT

The idea of TrafficCheck.at is to develop an IT-tool to collect data about infrastructural road and traffic conditions in urban areas. Based on the idea of urban sensing these data are not only collected by means of sensors but also by road users themselves. They continuously gather, process and share information about their environment [1] and send it via smartphone or PC from home to a central administrative service point where it is processed. Therefore TrafficCheck.at will be a helpful tool for public administrations to efficiently derive tasks – like repairing damaged traffic lights, fix defaults or in terms of quality management evaluate specific aspects of traffic light signal regulated intersections (TLSRI).

Traffic light facilities play an important role in urban traffic systems and significantly affect the road safety and quality of traffic at intersections. Quality management implies the evaluation of the operating reliability, traffic flow and traffic safety. The evaluation system is the centre of quality management. Friedrich et al. [2] distinguish between parameters for the quality of the traffic flow and parameters for the assessment of traffic safety. Documentation about the implementation and application of theoretical basics is rare. One example from Germany is the programme “Staufreies Hessen 2015” (Hessen clear of traffic jam 2015) [3]. Experts intensively work on the development of manuals and the definition of guidelines for the quality management at traffic light facilities in Austria (e.g. the Austrian Association for Research on Road–Rail-Transport (FSV) [4]) which proves the actuality of the issue. Existing regulations to evaluate traffic and road conditions mainly follow parameters which can be measured physically (such as speed) or are objectively statistically ascertainable (such as the number of traffic accidents). The only qualitative evaluation is done with options like poorly, satisfying or very good. [5] For a more elaborated approach a subjective evaluation of the different road users would be of great value. Especially specific user groups (like seniors or people with restricted mobility) are not considered in present proposals [6].

Another interesting possibility is the integration of complaint management into the quality management like the Viennese Info line of Road and Traffic provides [7]. Citizens have the possibility to deposit any kinds of complaints connected with infrastructural issues of roads and traffic flow via telephone. EU projects like HOTEL (How to analyse life quality) or ASI (Assess implementations in the frame of the Cities-of-tomorrow) developed instruments for surveys where citizens are able to assess traffic infrastructure regarding their own quality of life [8 & 9]. In the EU project WALCYNG [10] specific evaluation criteria for the product “walking” were defined. Social climate, health (e.g. short green phases cause stress for old people), safety (e.g. safely guided green phases for pedestrians without turning traffic) represent a few of these aspects which were starting points of the online-tool among others. Besides the technical aspects of user-oriented criteria of quality assessment technological developments open up new possibilities for citizens to deposit their opinions and perceptions at any time and any place. Urban sensing programmes enable users to systematically reflect, evaluate and subsequently change their environment by using mobile phones and Web access [11]. Furthermore the knowledge of users to generate and design new and individual products can be processed – Hippel created the term user innovation in this context [12]. The tool means an additional chance for public institutions to improve the product development and gain essential input for their services offering an innovative form of access.

2. RESEARCH METHODS

Several different empirical research methods were combined to develop a catalogue of reliable evaluation criteria. Previous studies and research work were determined. This State-of-the-art report contains the following topics:

- Under which circumstances are participation processes able to run successfully?
- Concept of “urban sensing”
- Important aspects according to the design of an online-tool (for e.g. layout and usability)

To fully consider the needs of the different road user groups, four focus group interviews with a total of 22 participants were carried out – one with pedestrians, one with bikers, a group with seniors and one where persons with restricted mobility (visually or hearing-impaired, people in wheelchairs) discussed their diverse opinions and perceptions. The empirical research focuses on un-motorized road users and their needs. The tool can still be used by motorized traffic users. Crucial points of the interviews were:

- What should be evaluated? (e.g.: times to cross, visibility conditions)
- How should the evaluation look like ("usability")?
- Requirements of the system to make it user-friendly ("design for all")
- Which additional features of the tool could be useful?

Based on the results of the literature analyses and the focus group interviews 20 experts from different disciplines discussed contents of the online-tool and tried to specify the requirements of the system. Traffic planners, representatives of stakeholder groups like pedestrian and biker associations, associations of people with different kinds of disabilities, representatives of public institutions and services such as Municipal Departments participated at this workshop. In small thematic groups the experts worked on the following tasks:

- What are crucial aspects connected with TLSRI?
- Which criteria are 'Must haves' of the system – that it will be a helpful tool for the administrations?
- What are the motives for traffic participants to use an online-tool like TrafficCheck.at?

3. RESULTS

3.1. Results of the empirical research

Apart from collecting expectations and requirements of potential user groups and existing problems at TLSRIs, main aim of the focus groups and the expert workshop was the construction of the evaluation system. This evaluation scheme represents the heart of the online tool. The first part of the scheme gives the user the opportunity to report a dysfunctional traffic light. The second part is based on the results of the empirical research and represents the quality evaluation scheme. Relevant issues for this differ depending on the individual user/ user group. Furthermore the administrative employees also have their own ideas and expectations of such an online-tool. Considering these different requirements TrafficCheck.at merges the results of the focus group interviews and the workshop to an evaluation scheme illustrated in the following Figure 1:

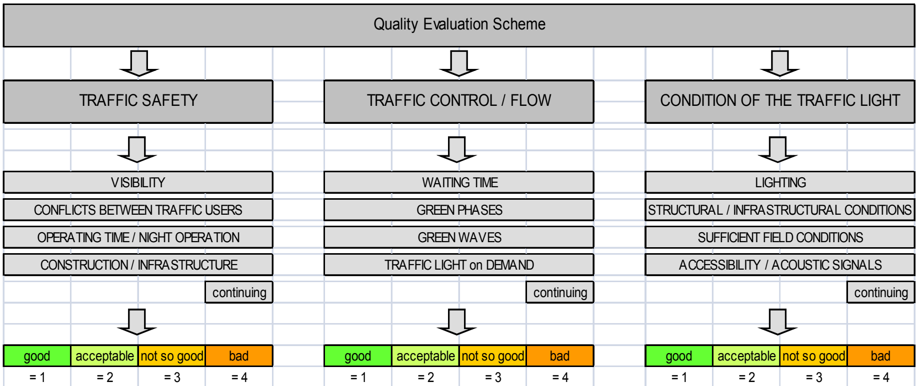

Figure 1: Quality Evaluation Scheme

This evaluation scheme consists of three main evaluation criteria which are further divided into four sub-criteria users are able to comment on. Choosing one criterion, users evaluate it with categories from 1-4. Afterwards the user has the opportunity to send a more detailed message.

At this point a few of the criteria shall be selected (as examples) to clarify the connection to and the importance of the previous empirical research for the structure of the online tool.

"Visibility" for example contains the visibility of the different road users which was important for the participants of all four focus groups. Pedestrians for e.g. fear they are not or too late seen by right turning car drivers. The bikers` problem is a restricted view caused by parking cars in the vicinity of road crossing. This evaluation criterion also contains the visibility of signals which gains increasing significance considering the elderly or visually impaired people (e.g. too little luminosity). The same problem appears in connection with ground markings which might wear out because of a steady drive over or rain and snow. The experts on the workshop especially emphasised the aspect "Construction/Infrastructure" in terms of the safety of traffic light installations. This contains the offer and construction of pavements, cycle paths, motor vehicles and bus lanes which was also mentioned in all of the focus groups. The group of the bikers for example stated that their lanes often collide with bus lanes and therefore lead to conflicts with the public transport. The same applies to crossings with sidewalks which is a crucial problem especially for seniors or persons with reduced mobility due to hearing loss. Another infrastructural problem is caused by too high constructed pavements which are an insurmountable barrier for people in (electric) wheelchairs.

Regarding the "Traffic Flow" the participants of all focus groups mentioned problems with the traffic light control which is mainly based on the motorized traffic (e.g. "Green Wave"). "Green Phases" are too short to cross the street in particular for seniors or impaired people. On the other side the group of the bikers spoke of an "over regulation" of the city. They as well as the pedestrians suggest traffic lights with "Activation on Demand" – mainly at night.

Within the main criterion “Condition of the Traffic Light” sufficient “Lighting” of intersections is vital for pedestrians because unlike motorized drivers or bikers they do not have a self-shining headlight system at their disposal. As emerges from the previous illustrations “Accessibility” is an important aspect to provide unlimited access to and use of the traffic system. This includes lowering the pavement in crossing areas for people in wheelchairs, tactile guiding systems and acoustic signals for visually impaired persons as well as clearing the streets from unnecessary and unexpected barriers.

3.2. Screenshots

Entering TrafficCheck.at online the user needs to take the following steps (illustrated in the screenshots of Figure 2):

3.2.1. Registration

The user has to register with username and password. In the workshop the experts agreed on a limited access to the evaluation tool. Especially employees of administrative institutions pointed out the risk of user abuse of the tool and stressed the importance of (at least) minimal user identification. Another aim of the registration is the possibility for the user to save messages at any time of the entering process and edit their feedback at a later time.

3.2.2. Means of transportation

In the first screenshot of Figure 2 users specify the means of transportation they are moving with respectively from which point of view each user is evaluating the traffic light facility – as pedestrian, as car driver, as biker or as user of public transport. This information is important for the administration, to put the user feedback into a broader context.

3.2.3. Map based Location

The next step users take is to locate the traffic light facility they are going to evaluate. The current position of the user can be seen on screen (2 in Figure 2). Additionally there is the possibility of address search. Traffic light systems within a radius of x metres appear on the screen (3 in Figure 2) and the users specify the one they like to evaluate.

3.2.4. Type of message

In screen 4 (Figure 2), the type of message the user will send has to be selected – either a defect or a quality evaluation of the traffic light system. In the workshop this differentiation of the messages turned out to be the most important aspect for the administration.

3.2.5. Additional information

After entering the message following the form provided users can add further information (screen 5 in Figure 2). A photo can be uploaded, saved messages can be further edited and users are able to check details of their message.

Figure 2: Screenshots

4. CONCLUSION

The focus group interviews and the discussion at the workshop opened a dynamic dialogue between the different groups of road users on the one side and traffic experts and stakeholders on the other side. Thus various demands on the TrafficCheck.at platform of different user groups were identified which significantly contributed to the user oriented applications, in particular to the evaluation scheme of this online-tool. The prototype of TrafficCheck.at will be presented on the ITS World Congress in October 2012 in Vienna.

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SPEED CHOICE MODEL OF CURVE ENTERING BASED ON NATURALISTIC DRIVING DATA

Akihiko Takahashi and Motoyuki Akamatsu

ABSTRACT: A prediction model based on naturalistic driving on ordinary roads is proposed. Driving behaviour at 69 curves obtained from a Japanese driving database was investigated, and a curve entrance velocity model was obtained as a prediction function of two arguments, the mean curvature radius and the velocity tendency of the curve. Velocity tendency is a newly introduced curve characteristic that describes the virtual velocity if the curve were not there. The precision of the model and error factors are discussed.

1. INTRODUCTION

Unlike driving on a straight section of road, curve negotiation requires a driver's conscious control to avoid lane deviation. Although accidental lane departure is rare, excess speed easily causes unexpected and uncomfortably large lateral acceleration. Future safety systems should predict a driver's velocity control before entering a curve. Curve velocity selection is a problem of ergonomics because drivers control the velocity based on driver comfort or for other reasons not directly related to the vehicle's mechanical limits with respect to centrifugal acceleration.

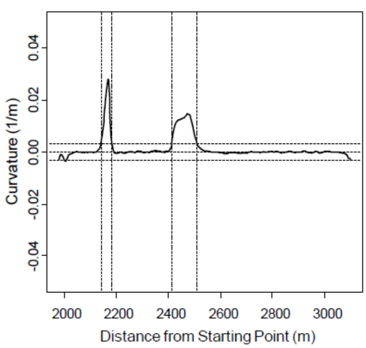
From a practical point of view, such a model should be based on observations of driver performance in the real world. The importance of such naturalistic driving research has been well recognized in the last years, and several projects have been reported such as the 100-Car Naturalistic Driving Study from Virginia Tech[1] and the driving database of Volkswagen AG Group Research[2]. Near-accident cases and high-speed driving cases have been well investigated with the aim of accident prevention. Reports involving curve-speed control in safe situations were rather few. Emmerson's work is an early case[3][4]. In this study, vehicle velocities were collected at several curves and a simple relation between speeds and the curvature radii was derived. Recently, Tate derived a similar model through instrumented car experiments[5]. Both studies addressed primarily highway driving.

In contrast, the present study investigates curve passing on ordinary roads containing both slow traffic and faster traffic. Naturalistic driving data were obtained from a large-scale Japanese driving database.

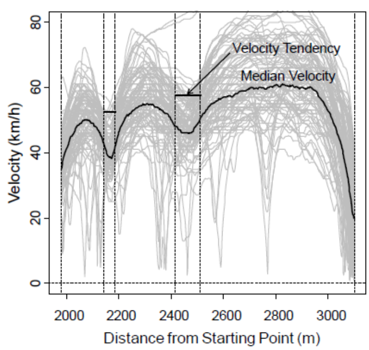
2. ANALYSED DATA

The driving database is one of the accomplishments of the Japanese project "Behavior-based Human Environment Creation Technology" (1999 to 2003) sponsored by the New Energy and Industrial Technology Development Organization (NEDO) and distributed by the Research Institute of Human Engineering for Quality Life (HQL)[6]. The database contains about 2300 trips on nine courses of about 10km driven by 4 to 28 volunteers. Specially equipped cars were used for data collection.

In the present study, a curve was defined as a section of road with curvature radius of less than 300m, corresponding to a steering wheel angle of approximately 15 degrees. The road curvature radius was estimated using yaw angular velocities $\varphi(t)$ and vehicle velocities $v(t)$ from the database. The moment curvature radius a vehicle experiences at time t is $R(t) = v(t)/\varphi(t)$, and the radius $R(t)$ was converted to a function of running distance $R(l)$, where l is the running distance from the starting point $l(t)$. GPS location data was used for calibration. To avoid incidental outlier cases, the median of estimated curvature radii at each location was used. One example is presented in Fig. 1(a) (in curvature form, namely the inverse of the curvature radius), with a section containing two curves. The dashed horizontal line represents 1/300 (1/m), indicating the border between curve sections and straight sections. Curves that were unsuitable for finding the general effects of a curve were removed, such as locations near traffic signals or crossings where stopping is frequent or necessary, narrow roads where the effect of an oncoming car is not negligible, and segments experiencing frequent traffic jams. Sequences of multiple curves separated by short straight sections were also removed to avoid the mutual effect of the curves. Finally, 69 curves (34 right turns and 35 left turns) were obtained and 4 to 28 participants drove totally 265 to 316 times trough the curves. For the analysis, vehicle velocity data was converted to a function of the running distance $v(l)$, similar to the curvature data. An example of velocity data is given in Fig. 1(b). The figure presents velocity profiles of 100 trips in the same segment as in Fig. 1(a) (drawn in gray). Incidental deceleration often occurred because of the natural environment of an ordinary road, such as the actions of a preceding car, and various other phenomena, causing variations in the velocity profile and acting as noise in the study of the general effects of curves. To avoid such interference, the median of the velocity data was used, as seen in Fig. 1(b). Using median data cancels random phenomena and inter-/intra-personal differences and should reveal the essential effects of the curves.



(a) Curvature Profile



(b) Velocity Profiles of 100 Trips, and Median Velocity

Fig. 1. Curvature and Vehicle Velocity on a Road Segment with Two Curves

3. ANALYSIS

3.1. Curve Characteristics and Vehicle Velocity

This study analysed the median of the vehicle velocity at the entrance of a curve v_{enter} as the characteristic velocity while transiting a curve. The curve entrance point was defined as the location where the curvature radius drops below 300m. This was previously defined as the border of a curve and a straight section. The aim of the analysis was to determine the curve characteristics that affect vehicle velocity as the driver prepares to enter a curve. The following potential factors were investigated.

- Mean curvature radius from the entrance to the exit of a curve, R (m)
- Curve length from the entrance to the exit, L (m)
- Total rotation angle from the entrance to the exit, (deg) □
- Regulation speed $v_{regulation}$ (km/h)
- Lane width of the curve, w (m).

Table 1. Curve Characteristics

	Mean Curvature Radius (m)	Curve Length (m)	Total Rotation Angle (deg)
Min	20	2	1
Mean	148	48	26
Max	257	122	90
SD	65	24	22

Speed Regulation	
30km/h	16 curves
40km/h	46 curves
Not Specified	7 curves

The range of the lane width was too narrow (2.9 to 3.2m) to estimate its effect on velocity, and this factor was omitted in the later analysis. Other characteristics of the obtained curves are given in Table 1. Three continuous factors, the mean curvature radius, length, and rotation angle, are not independent and are related by the equation R= θ /L*(θ /180). R and θ are also strongly correlated (Fig.2), which means that a curve of large rotation tends to have a sharper curvature. In the analysis, only R is used because it seemed difficult to separate the influences of R and θ.

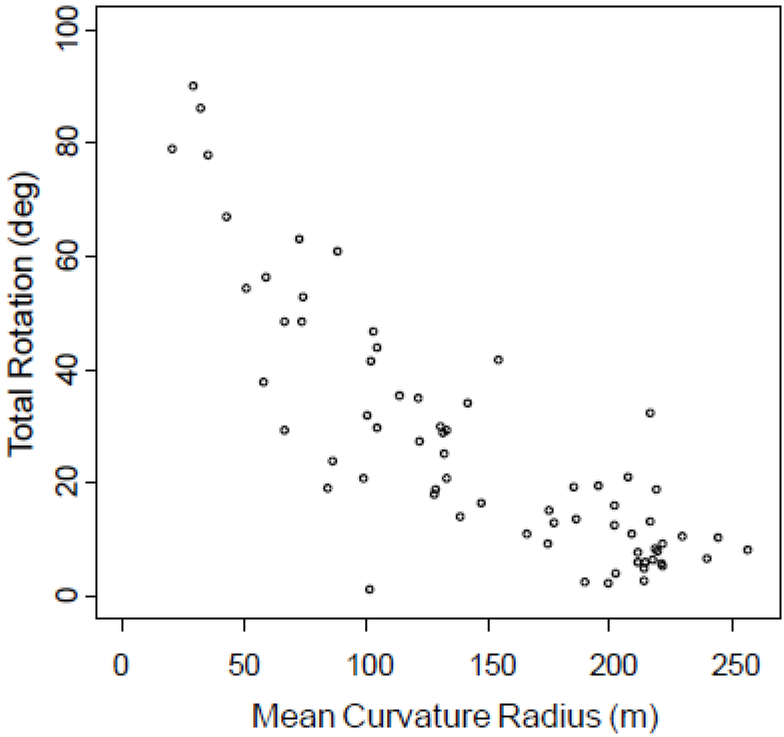


Fig. 2. Rotation Angle vs. Curvature Radius

Finally, three factors, *R*, *L*, $v_{regulation}$, were selected as independent variables. Scatter plots of these variables and the curve entrance velocity *v*enter are presented in Fig. 3. Regulation speeds are indicated by different marks.

Curve length and regulation speeds have almost no relation to *v*enter. With the mean curvature radius, a slight relation is seen. Intuitively, the velocity will be reduced on a sharp curve, but the existence of a wide velocity distribution due to curvature radius suggests that there are other factors reducing the driver's speed. The factors of speed decrease can be separated into two categories: factors unique to transiting curves and factors that are common to curves and straight sections. In straight sections, many factors still influence vehicle velocity, such as the road-surface state (bumps and clarity of road markings), objects near lanes (buildings, guardrails, utility poles, and entrances to parking areas), other traffic participants and pedestrians, the time of the day, and so on.

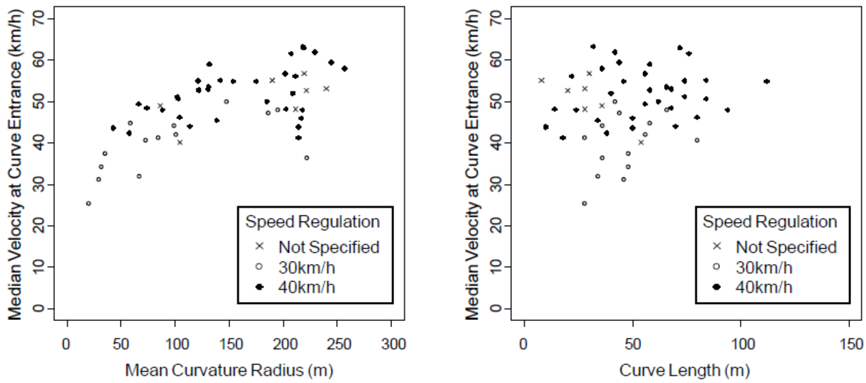


Fig. 3. Entrance Velocity vs. Curve Characteristics

In order to concentrate on the effects of the curve, these common factors were reduced to a 'velocity tendency' $v_{tendency}$, which is the virtual velocity on the curve that would apply if the curve were not there. The mean of the peak velocities on the two straight sections before and after a curve was used as an estimator. Figure 1(b) presents the estimated velocity tendencies of two curves. A large range of velocity tendencies was obtained (37 to 65km/h; mean 51km/h, SD 7.2km/h).

Curves were classified into three levels based on $v_{tendency}$: slower (under 45km/h), middle speed (45km/h to 55km/h), and faster (55km/h and above). The relation between the curve characteristics and the entrance velocity v_{enter} for each $v_{tendency}$ level is plotted in Fig. 4, with the levels indicated by different marks. In the scatter plot of mean curvature radius vs. velocity, the relation looks clear in each level. When the radius is small, velocities are lower, and when the radius becomes large, velocities converge to certain limit velocities.

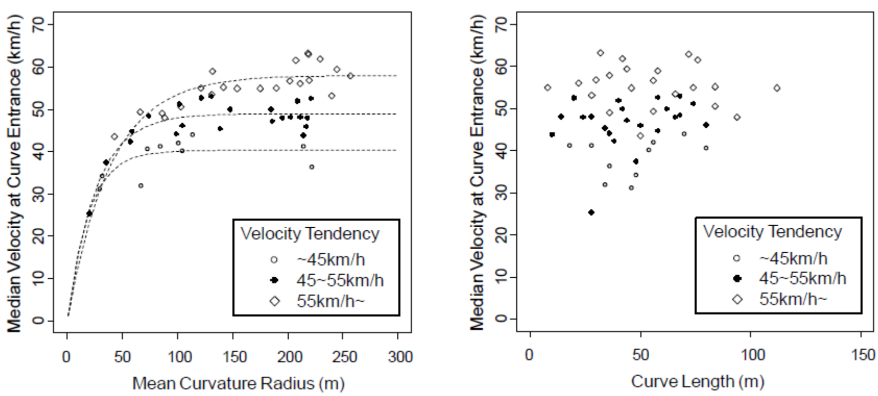


Fig. 4. Entrance Velocity and Velocity Tendency at Curves

3.2. Model for Predicting Curve Velocity

Emmerson stated that the mean velocity at the middle of a curve can be described as an exponential function of the curvature radius. Similarly, the relation between the curvature radius and velocity by *v*tendency level can be fitted to an exponential function as follows:

$$v_{\text{enter}} = v_{\text{limit}} * (1\text{-exp}(-R/\beta)), \qquad (1)$$

where v_{enter} is assumed to be zero when the radius is zero. When the radius becomes large, the velocity converges to v_{limit}. β is a shape parameter. These unknown parameters were estimated using the Gauss-Newton method to minimize the mean square error in predicting the velocity. The estimated parameters are listed in Table 2. The fitting curves are also displayed in Fig. 4.

Table 2. Model Parameters

	v_{limit} value (estimated SD)	β value (estimated SD)
Velocity Tendency < 45km/h	40 (1.3)	19 (4.1)
Middle Velocity Tendency	49 (0.7)	26 (2.6)
Velocity Tendency > 55km/h	58 (0.9)	39 (4.2)

One concern is that in this model treats continuous velocities as discrete values, and this discretization can result in prediction errors. Linear regression gives simple estimates of two parameters as continuous functions of v_{tendency} as follows:

$$v_{\text{limit}} = 0.97 * v_{\text{tendency}}, \text{ and } \beta = 0.55 * v_{\text{tendency}}, \qquad (2)$$

where the estimated SD of the coefficients is 0.009 and 0.07 respectively.

Through Eqs. (1) and (2), the median entering velocity of a curve can be predicted using the mean curvature radius and the velocity tendency. A histogram of the prediction errors is presented in Fig. 5. Almost all of the errors are within 6km/h, and the SD was 2.3km/h. Compared with former models where *v*tendency is discrete (also plotted in the histogram), the continuous *v*tendency model improves the prediction precision.

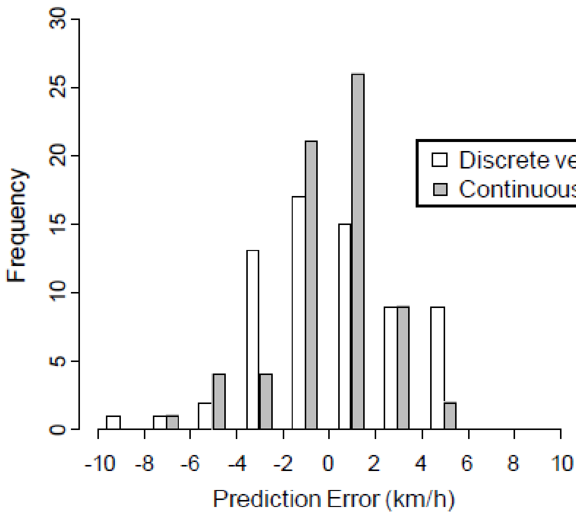


Fig. 5. Parameters of Models vs. Velocity Tendency

4. DISCUSSION

Tate et al. introduced a variable of similar concept, called the speed environment, in their velocity model. This was defined and estimated as a traffic characteristic of rather longer road segments[5]. In both studies, there was an implicit assumption that there is little change in velocity outside of a curve. To examine this assumption, Fig. 6 presents a scatter plot of peak velocities before and after a curve. From the figure, it is not apparent that this assumption is true. Actually, such speed changes can cause difficulty in speed prediction. In order to clarify the effect of speed changes, the model was re-built using 42 curves (*R*: 32~344m), in which the velocity difference before and after the curves is less than 5km/h. The model reduced the prediction error (SD: 1.9km/h). This result suggests that local changes in the velocity tendency can be critical for estimation.

Another concern is that it seems difficult to estimate the velocity tendency where a straight section is too short to permit acceleration. A sequence of curves can reduce the velocity tendency around a rather long section. This mutual effect of curves is another remaining problem.

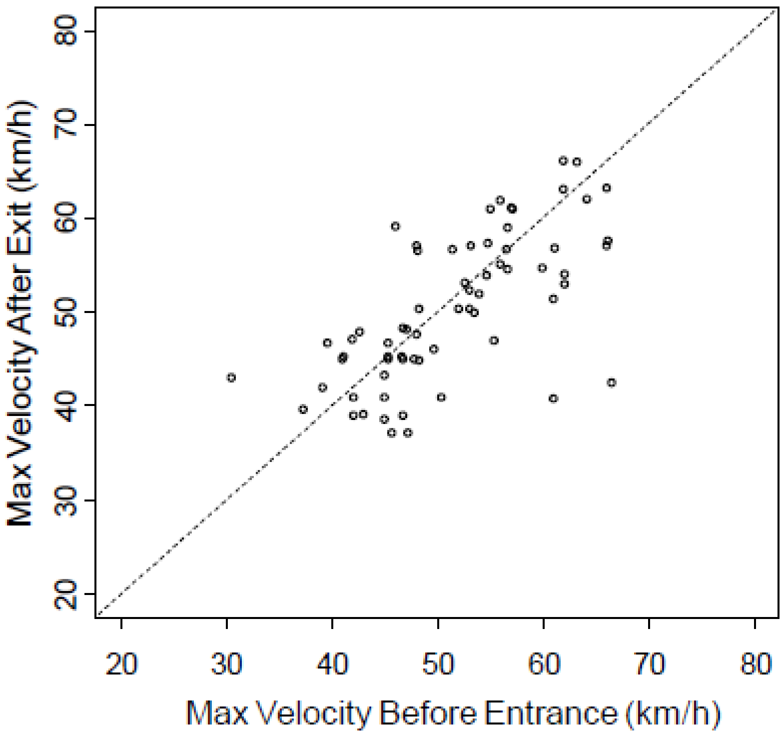


Fig. 6. Peak Velocities Before and After a Curve

5. CONCLUSION

A model for predicting curve entrance velocity was proposed. The introduced model is a function of both the mean curvature radius and velocity tendency. Although the set of analysed curves includes slow traffic areas, the prediction error was rather small. The velocity tendency is a representative velocity around a curve, and it is assumed that this velocity is constant before and after the curve. However, this assumption is not always correct for ordinary roads, and this fact was shown to be a factor in the prediction error. Distinguishing the causes of such local changes in velocity is another problem of real-world driving research to be investigated.

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A GROUP APPROACH TOWARDS AN UNDERSTANDING OF RIDERS' INTERACTION WITH ON-BIKE TECHNOLOGIES. RIDERS' ACCEPTANCE OF ADVANCED RIDER ASSISTANCE SYSTEMS

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ABSTRACT: The development of assistive systems and intelligent transport systems (ITS) for improving the safety of powered two-wheelers (PTWs) is a pressing issue. Assistive systems for cars are well known and increasingly popular but for PTW riders the development of Advanced Rider Assistance Systems (ARAS) and On-Bike Information Systems (OBIS) hasn't progressed far enough yet. Estimates suggest that population-wide deployment of ARAS could reduce crashes by up to 40% (Rakotonirainy, A. et al., 2006 [7]). Within the 2BESAFE project the factors that affect the acceptance of ARAS and OBIS of PTW riders and the obstacles that may hold PTW riders off from the use of assistive systems have been identified. A literature review, focus group interviews and an online survey have been conducted. The results show that the acceptability of systems depends on their function. The acceptability is also higher for systems that were perceived to be more useful in emergencies. Survey respondents raised several concerns regarding the acceptance of assistive systems for PTWs. Respondents of the on-line survey felt that there is too much focus on assistive systems as a means of improving PTW rider safety, and less on the dangers that motorcyclists face actually from the actions of other road users.

1. RIDERS ACCEPTABILITY OF ASSISTIVE AND INFORMATIVE SYSTEMS

To make the implementation of the safety benefits of on-vehicle assistive technologies possible, it is essential to understand the barriers that may hinder the acceptance and proper use of the technologies. The purpose of this study is to understand the factors that are likely to influence riders' acceptance of ARAS and OBIS technologies. This can be accomplished through the literature review, focus groups and a large-scale online survey.

1.1. Literature review on assistive systems, crash types and concepts of acceptance and acceptability

For PTW riders few assistive systems have been developed. In 2006 eight safety enhancing ITS systems for motorcycles existed and were commercially available (Bayly et al, 2006 [2]). In the recently presented draft of regulations for motorcycles, the European Commission announced the intention to make Anti-lock braking system (ABS) on motorcycles with more than 125cc displacement mandatory by 2017 (VKU, 2011 [11]).

The potential benefit of certain assistive systems for the road safety of PTW riders can be better understood if we look at the different types of PTW crashes. The types of crashes appear to vary internationally, depending on a number of factors such as the prevalence of PTW riders or the reasons for riding the PTWs. Compared to car drivers, PTW riders are more vulnerable because of their lower driver's protection at a relatively high speed and lower stability. The relations between riding speed and the injury risk are well known, but less is known about the link between speed and frequency of crashes. The instability of PTWs can be exacerbated especially in emergency braking situations when the wheels may lock (Quellet et al, 2006 [6]).

In addition, PTW riders are less visible to other road users. The visual conspicuity as well as the sensory and cognitive conspicuity of PTW riders are lower. PTWs have low sensory conspicuity compared to cars and other vehicles due to their small size and their often dark colours (colour of motorcycle and/or colour of the motorcycle rider's clothing). PTWs have low cognitive conspicuity because they are inconsistent with drivers' expectations, in other words, car drivers expect other cars on the road (Brenac et al. 2006 [3]).

Many PTW crashes can be attributed to rider characteristics. The MAIDS study reported that human error on the part of the rider was a contributing factor in one third of crashes (ACEM, 2009 [1]). Novice riders can be considered as the rider group with the greatest injury risk (Gregersen et al. 2003 [5]).

There are a number of ways to classify assistive systems. Active systems act prior to crash occurrence and some of these systems can reduce the probability of a crash. Passive systems serve to reduce the effects of the crash once it has occurred or is occurring. Systems can also be differentiated according to the level of intervention with the rider's behaviour. Informative systems simply provide information; warning systems transmit alerts; and intervening systems take over the part of the riding task in certain situations.

Few studies addressed the acceptability of assistive systems for PTWs. In Australia Cairney and Ritzinger (2008 [4]) assessed acceptability of ISA (Intelligent speed adaptation), ACN (Automatic Crash Notification) and ABS and noted some barriers to the acceptability of specific systems, most of them related to the perceived benefits or effectiveness.

Technologies must be accepted by the intended users of the system. While the general public have little or no choice in deciding which road infrastructure-based ITS applications they interact with, they will have vital choice in deciding which in-vehicle or on-vehicle systems they will use. If assistive systems are not acceptable for the road users, they are unlikely to have a positive effect on driver behaviour and crash risk, or may even have a negative effect. Moreover, it is economically counterproductive to invest effort into designing and building technologies if the systems are not purchased by the consumer, or are purchased but never used (Van de Laan et al., 1997 [10]). Schade and Schlag (2003 [8]) distinct between acceptability and acceptance. They defined acceptability as a prospective judgement regarding a system that has not yet been adopted or experienced. In contrast, acceptance includes a behavioural or reactive connotation. Since most ARAS and OBIS are not yet implemented, it would therefore be more appropriate to use the term “acceptability” in reference to assistive systems for PTWs.

Within the literature review the following key constructs underlying most models of acceptability have been gathered: Usefulness, ease of use, effectiveness, affordability and social acceptability.

1.2. Methodology I: Focus-group Interviews

The data collection of this study was carried out in two stages. In the first step focus group interviews have been conducted in Austria and Germany. Based on this information, the online survey questions about the acceptance of assistive systems were formulated.

Group discussion is a method of empirical social research which focuses on thematic statements of a group and communication within a group. 2 to 2,5 hour long focus group interviews (FGIs) were conducted with groups of 7 and 8 motorcycle riders: two in Austria with commuters and recreational riders which were members of a motorcycle club and two in Germany with engineers, scientists and/or motorcycle riders of the BASt (Bundesanstalt für Straßenwesen) which focused on conspicuity related systems; in addition the FG-interviews based on experiences from interviews conducted previously with riders and focused on behavioural and safety issues in 9 European countries (A, CZ, Fin, F, GER, GR, I, P, S); in those interviews the assistive systems were discussed, and also the general familiarity with certain assistive systems, the riders’ experiences with these systems, perceived advantages and disadvantages of assistive technologies for PTWs and the suggestions as how to improve the systems. The discussions were focused primarily on Anti-lock braking system (ABS), Traction control system (TCS), Intelligent speed adaptation (ISA), GPS navigation; but also other less familiar assistive systems were commented on (e.g. advanced front-lighting system, vision enhancing systems, daytime running light, airbags, collision warning systems, Vehicle-to-Vehicle communication, following distance warnings, lane departure and lane keeping systems, brake booster, tire pressure control system, etc.). Besides, critical and erroneous riding situations where assistive systems could be helpful were discussed with the help of pictures and videos. In general, participants had a good knowledge of assistive systems, particularly based on experiences with passenger cars, but their attitudes were rather negative. The results from the questions provided sound information about which active and passive systems are typically considered useful or less important for PTW riders.

1.3. Methodology II: Online Survey, Motorcycle rider profiling questionnaire (MOPROQ)

The information obtained from the focus group interviews considerably influenced the development of the online questionnaire MOPROQ (Motorcycle rider profiling questionnaire). As general attitudes towards specific systems were rather negative in the focus group interviews, four specific riding situations in which assistive technologies might be helpful were identified and used for the development of the last part (MOPROQ 3) of the three part survey. The first two situations of the MOPROQ 3 questionnaire focused on stability and braking enhancing systems (ABS and TCS) as they are relevant for nearly all loss-of-control incidents. The third situation was created for the usage of crash avoidance systems (e.g. autonomous cruise control, lane keeping assistance, ISA, etc.) and the fourth situation was designed in order to provide information about the acceptance of informative systems (e.g. GPS).

As mentioned, the online questionnaire was divided in three-parts. The first part, MOPROQ 1, focused on socio-demographic data, such as age, type of motorcycle used, frequency of motorcycle usage or motivations for riding, riding practices or accident history. MOPROQ 2 was designed to explore the relationship between personality traits, such as e.g. anxiety or sensation seeking and certain attitudes towards risky riding behaviour - speeding or rule violations, and attitudes towards traffic safety. MOPROQ 3 focused on the attitudes and the acceptability of assistive and informative systems for the riders. The online survey was available in seven different languages (Czech, English, Finnish, French, German, Greek and Portuguese) and distributed by the partners of the 2BeSafe project. In total 6297 questionnaires were completed.

Aside from some differences in riding motivations across cultures (e.g. ‘riding bends’ - high motivation for riding for Finnish-speaking respondents in contrast to English-speaking respondents; ‘speed’ as high motivation for Greek riders etc.) the rating of the systems varied in different countries (e.g. ABS was rated the highest in the German survey, ‘Night vision’ was rated as most important in the French, English and Portuguese survey).

Ease of parking was rated very highly by the Greek participants, compared to the Finnish sample. This is understandable given that in Greece urban traffic is dense and parking represents a serious problem, whereas in Finland space is less of an issue. The same applies for increased mobility and the cost advantage.

Limitations of the survey concerned the online-tool (the sample was biased towards leisure riders of motorcycles, with few scooter riders, moped riders, or commuters), the language (riders could only participate if they were fluent in one of the seven languages used in the survey. This may have excluded or deterred participants from other countries), the distribution (for time reasons the survey was only available for a five-week period; lack of sufficient time to fully distribute the survey link), the qualitative data (open-ended sections were provided in order to make feedback possible – thus given the large sample size, it would have been very time consuming to screen fully the open-ended questions, and code them) as well as the fact that most respondents lacked direct experience with most of the assistive systems listed in the survey (given that the systems involve technology which is not widely publicised and/or not yet commercially available) which may have influenced the acceptance of the systems.

2. FINDINGS OF THE STUDY

The analyses of the survey data can be summarized in the following findings. The self reported overall awareness of assistive systems was high, with over 90% indicating some degree of familiarity with each system studied. The familiarity was greatest with systems that are widely available for motorcycle riders such as ABS and GPS, and systems that are well known from passenger cars. The acceptability of these systems depends on function, as the answers indicated greater acceptability towards informative systems (e.g., GPS, night vision) rather than assistive systems that interfere with the riding task (see Figure 1). In addition, acceptability was also higher for systems that were perceived to be more useful in emergencies, such as eCall (In-vehicle emergency call system in order to bring rapid assistance to drivers) and ABS. Also observed was a consistently low acceptance of systems such as Adaptive cruise control (ACC), Intelligent speed adaptation (ISA) and lane keeping assistant, which are perceived to remove some of the rider’s responsibilities. There is a distinct subgroup of PTW riders who ride primarily for fun or leisure and this group displays lower acceptance of assistive systems altogether.

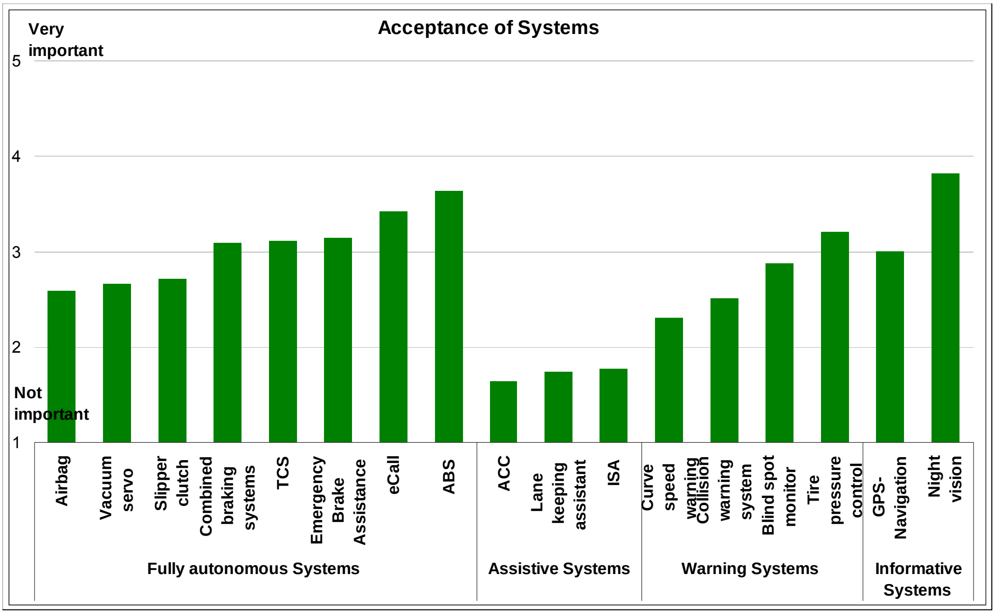

Figure 1: Acceptability of different systems (5 = this system is important for enhancing riding safety, 1 = this system is not important for enhancing riding safety)

2.1. General Indicators of Acceptance

Several variables were investigated as potential general predictors of acceptance. These included age, country, personality traits, riding frequency, riding practices, social norms for following rules, motivations for/and attitudes towards riding. There were three main general indicators of acceptance which differentiated between two acceptance clusters: perceived downside of riding; annual kilometres travelled by PTW; and frequency of riding on hard shoulders.

The two acceptance groups were identified by applying the Cluster analysis within the overall online survey sample; those were referred to as “low acceptance” and “moderate acceptance” groups, based on their overall opinions and attitudes towards four types of assistive systems: braking enhancing systems, traction control systems, distance warning systems and navigation systems. The “moderate acceptance” group showed significantly greater acceptance of all of the systems examined in the survey, with the greatest differences observed for TCS, ABS and related braking technologies (emergency brake assist, combined braking systems), curve speed warnings, collision warnings and airbags.

Unsurprisingly, the first indicator of acceptance, perceived downside of riding or risk acceptance, was a significant predictor of overall acceptance of assistive systems. This is consistent with Schlag's (1997 [9]) assertion that problem awareness is a necessary precondition for acceptance; if individuals do not perceive any specific dangers in riding a PTW, they will not be motivated to seek specific applications to improve their safety.

Riders' overall level of use of their PTW, in terms of annual kilometres travelled, was also a significant predictor of acceptance. Although there was not a complete linear relationship, riders in the high acceptance group were more likely to travel over 10000 km per year. As previously discussed, however, the relationship is not straightforward and to some extent this variable may reflect other characteristics, such as reasons for riding and typical usage of the PTW.

The final major predictor of acceptance was riding on hard shoulders to avoid slowing down behind cars. This variable, as well as positive attitudes towards speeding measured on the MOPROQ 2, predicted overall acceptance of assistive systems; those who demonstrated low acceptance of assistive systems were less likely to report riding on the hard shoulder or speeding. There are two ways of interpreting this finding. First, accepting the results at a face value, it appears positive (albeit slightly counter-intuitive) that riders who are more likely to engage in risk-taking behaviour also display higher acceptance of new safety technology, meaning the systems are likely to be adopted by those who need them most. However, given that the current study used self-report methodology, there is an alternative interpretation: it could be the case that riders who have lower acceptance of assistive systems downplay the risks or believe that their relative risk of accident is lower (e.g. compared to less experienced riders).

Despite the variation in levels of acceptance, the overall acceptance was relatively low for all systems, especially when compared to the levels of acceptance for equivalent systems that are available in passenger cars.

2.2. Riders concerns about assistive technologies

Survey respondents raised several concerns regarding the acceptance of assistive systems for PTWs. Some respondents, particularly the more experienced riders, stated that PTW rider safety could be better improved through provision of a more comprehensive and regular rider training, rather than by developing new assistive systems. There was a particular concern that assistive systems may counteract rider training, because riders will over-rely on the system and consequently will never learn, or will lose, the proper technical riding competences that help them avoid or/and resolve dangerous situations. Riders objected to the idea of systems that remove their responsibility to control the PTW. Most of the respondents believed that assistive systems, especially technically sophisticated ones, are too expensive. It is considered impractical to fit assistive systems on PTWs retroactively, especially on scooters and smaller motorcycles, due to both size and cost considerations. Some systems are perceived as being potentially useful in principle, including ABS, but riders have concerns regarding the technical maturity and reliability of the system. This lack of trust in the system affects their willingness to accept it. Many riders expressed scepticism about industry motivations, believing that manufacturers are more motivated by potential profits than genuine safety concerns for riders. Respondents also felt that there is too much focus on assistive systems as a means of improving PTW rider safety. They pointed out that many of the dangers that motorcyclists face actually result from the behaviour and actions of other road users. As such, some riders believe that assistive systems that focus on the PTW rider will not greatly benefit their safety, and that more effort should be put into improving awareness and understanding between different types of road users.

The results also revealed some system-specific indicators of acceptance. The riders, who responded the questionnaire, generally objected to systems that interfere with their responsibilities as a rider (e.g. ISA, ACC). The riders showed greater acceptance of systems that will provide obvious benefits in emergency situations, such as automatic crash notification. Also well established systems, which are widely popular and trusted, having obvious safety benefits and therefore considered technologically mature (e.g., ABS) scored higher acceptance. Riders also expressed concerns that some systems may lessen the driving skills of the rider and that some assistive systems, which are widely available for passenger cars, may be too costly for subsequent fitment on most PTWs.

The results suggest that there is a large potential how to increase acceptance, either through changing the riders' attitudes towards the technology or by changing the technology itself. The majority of riders see the training of the riding skills as more beneficial than the use of assistive systems. The evidence suggests that riders will rather accept systems that they perceive as useful and effective.

3. CONCLUSION

The aim of this study was to examine factors that affect PTW riders' acceptance of ARAS and OBIS, collectively referred to as "assistive systems". The results of a large-scale international survey revealed that both general and system-specific factors influence acceptance of assistive systems. In terms of general indicators, the sample was divided into two groups: a low acceptance group and high acceptance group. These groups differed in their attitudes towards riding and their riding practices. Those in the high acceptance group perceived a greater downside to riding, but were also more likely to report engaging in high-risk riding behaviours such as riding on the hard shoulder and speeding. In terms of system-specific issues in general, riders were more accepting towards systems that provide obvious benefits, such as eCall, or systems that do not substantially interfere with the riding task. Overall, however, it appears that acceptance of PTW assistive systems is relatively low compared to acceptance of equivalent systems in passenger cars. This is likely because of the substantial differences between riding and driving, both in terms of motivations for riding, which influence willingness to accept interference from assistive systems, and physical differences between PTWs versus cars, which influence the practicality, effectiveness and affordability of assistive systems for PTWs relative to cars. From the results of the open-ended questions it emerges that from a riders perspective the focus must lie on enhancing riding skills and riders training (especially for risky riding situations such as slippery roads, surfaces, curves, visibility conditions etc.) especially for novice riders, rather than on ITS systems. In this regard the understanding of the specific condition of other road users must be promoted systematically. Further a focus must be laid on interaction between road users in order to minimise uncertainty and communication breakdowns.

The main limitation of using the large-scale international online-survey concerned the fact that only a limited number of motorcycle riders were reached (recreational riders of motorcycles, with few scooter riders, moped riders, or commuters) due to lack of time and form of distribution: the online-survey was basically completed by those who were able to use the relevant internet-forum or those who were part of an associations or members of motorcycle clubs. Further research must therefore attempt to gather a more representative sample of riders.

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