AN INTEGRATED AND MULTIDISCIPLINARY APPROACH FOR STUDYING USE AND ACCEPTANCE OF NEW DRIVER SUPPORT SYSTEM: THE FRENCH NATIONAL PROJECT ON INTELLIGENT SPEED ADAPTATION (LAVIA PROJECT)

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ABSTRACT

Speeding on the roads is acknowledged as a serious societal and public health issue in all countries. During the last twenty years, much research has been devoted to studying the potential impact of new driver support system, such as Intelligent Speed Adaptation (ISA) systems for contributing to solve this issue. The aim of this paper is to present the multidisciplinary and integrated evaluation process of the French project on ISA (the LAVIA project). The LAVIA systems were evaluated on the basis of four main dimensions: usability, usefulness, acceptability and safety. Definitions of the four dimensions are given and the survey, measurement and observation methods that were employed to evaluate them are presented. The main results obtained and their contribution to the overall evaluation process are presented and discussed.

1. INTRODUCTION

Speeding on the roads is acknowledged as a serious societal and public health issue in all countries. During the last twenty years, much research has been devoted to studying the potential impact of new driver support system, such as Intelligent Speed Adaptation (ISA) systems for contributing to solve this issue (for a review see for example Jamson et al., 2006). The purpose of this paper is to present the overall evaluation process of the French project on ISA (the LAVIA project) and the main results obtained so far. The LAVIA project initiated by the French Ministry of Transport in 2001 aimed at studying the acceptability and use of speed limiters designed to help drivers keep their speed to within regulatory limits, and analysing the behavioural changes associated with the use of the system and their potential impact on road safety.

The system studied operates in three modes that are more or less restrictive in terms of controlling the vehicle's speed: 1) An “Advisory” mode, in which the driver receives information (displayed on the dashboard) about the prevailing speed limit and his
possible infringements of the regulatory threshold; 2) An “Active Voluntary” mode, where the vehicle's speed is effectively limited, but the driver can activate and deactivate the limiter at his convenience. Furthermore, the driver has a kick-down device available which enables him to neutralise the limiter temporarily. 3) An “Active Mandatory” mode in which the driver cannot deactivate the limiter but still has the kick-down device available.

An integrated and multidisciplinary evaluation approach was proposed focusing on four dimensions classically employed to evaluate a new product, namely: usability, acceptability, utility and safety (Lassarre and Saad, 2006). The following diagram summarises the main dimensions taken into account in the evaluation process, the investigative approaches implemented for taking account of these dimensions, and their contribution to the evaluation (Figure 1).

![Figure 1: The overall evaluation process (Lassarre and Saad, 2006)](image)

2. THE FOUR DIMENSION OF THE EVALUATION

2.1 Social and functional Acceptability of the LAVIA

Driver support systems such as LAVIA represent new objects that has to be integrated in the social norms and values associated with motoring and in driving practices that are well established, assimilated and structured with experience. It is thus important to comprehend the various dimensions likely to influence drivers' acceptance of this new system. In our research, and in line with (Nielsen, 1993), we differentiate social dimensions (beliefs, attitudes, norms, etc.) and functional dimensions (utility, reliability, ease of learning and appropriation, etc.) of acceptability. We also take into account the drivers' experience with the system (Schade and Schlag, 2003) and examine a priori acceptability (without experience with the system) and after-use acceptability.
2.2 Usability

According to Nielsen (1993), usability is an essential dimension of practical utility, and in turn of practical acceptability. Usability is defined, according to the ISO 9241 norm, as "the degree to which a product can be used by identified users to attain predetermined goals effectively, efficiently and satisfactorily, within the context of a specified use." Usability can be measured by ease of learning and ease of use, as well as by effectiveness and efficiency criteria (Nielsen, 1993), knowing that the designers of a system often made tradeoffs between these criteria.

2.3 Utility

The evaluation of utility from the designer point of view is similar to the evaluation of effectiveness in the traditional sense used in the field of transport and road safety. It entails assessing the system's ability to attain an objective laid down by the designers, which is to enable motorists to abide by speed limits while driving a vehicle. Depending on the LAVIA modes, which range from Advisory to Mandatory active, evaluating effectiveness will entail quantifying the degree of compliance achieved by the driver when using the system. (Lassarre and Romon, 2006)

2.4 Safety

Safety is assessed in relation to the reduction in the risk of a material damage or injury accident. LAVIA is supposed to yield a gain in safety through better compliance with speed limits, especially as regards fatal accidents. An evaluation of the system's a priori effectiveness as regards accidents will be produced, calculated on the basis of the attributed risk, by comparing two distributions of speed with and without the use of the system.

3. METHODOLOGY

The experimental plan was adapted to each dimension of the evaluation: a questionnaire survey concerning social representations and acceptability on a representative sample of drivers living in the experimental area (N=1005); a pre-experiment or pilot study in real driving situations for assessing usability and functional acceptability on a sample of 12 volunteer drivers using prototypes equipped with the LAVIA system; and an experimental plan for assessing ex post utility and social and functional acceptability on a sample of 92 volunteer drivers living within the experimental area and having drive with a vehicle equipped with the LAVIA for their daily travel during two months. The inter-dependencies and complementarities of the various surveys and experiments have to be emphasised. This means 1) that each phase of the evaluation process feed the following phases by providing relevant information for designing data collection and/or data analysis tools; and 2) that the results of each survey and experiment provide a specific insight on the various dimensions of interest, which have to be discussed and integrated along the evaluation process. The final step of the evaluation will consist in putting in perspective and weighing the various results.
obtained in order to formulate reasoned recommendations for future research and/or development strategies.

3.1 The experiment

The experimental area was located in the Paris region, near Versailles and the roads in the experimental area totalled 1,289 km in length, including urban and rural roads and motorways, with speed limits ranging from 30 Km/h to 130 km/h. A fleet of 22 vehicles was equipped with the LAVIA and data recording systems and used during the pre-experiment and the experiment in real driving situations. Each participant drove an equipped vehicle for two months, consisting of four consecutive two-week periods with an imposed succession of modes for the system: neutral, Advisory, Active Voluntary and Active Mandatory. At the end of the trial of each mode (i.e. every two weeks) its acceptability to drivers and its functional dimensions were assessed by questionnaires.

3.2 The psycho-sociological surveys

The psycho-sociological surveys were carried out in the experimental area for studying social representations of, and attitudes towards speed and speed limits, and the system's acceptability before (N=1005, Pianelli, 2008) and after the effective use of the three modes (Advisory, Active Voluntary, and Active Mandatory) in real driving situations (N=92).

4. MAIN RESULTS

It is not possible in the scope of this paper to present in detail the results obtained in the various surveys and experiment carried out during the LAVIA project. We will mainly provide a short overview of the main results obtained so far as regards 1) drivers’ acceptability of the LAVIA systems and how acceptability evolved after the experience of the three modes in real driving situations; 2) the usage of the system and the effectiveness of the three modes in terms of speed compliance during the experiment.

These results illustrated and confirmed two important issues that, from our point of view, deserve further research: one is related to the levels and the dynamics of drivers’ acceptance of new support systems; the other one is related to the inverse relationship observed between effectiveness of the systems and their acceptability to drivers, probably mediated by the level of constraints imposed on drivers’ activity and priorities by the systems’ usage.

4.1 Driver’s acceptability of the LAVIA systems

4.1.1 Social representations of speed and a priori acceptability of LAVIA

Four groups of drivers were differentiated on the basis of their representation of speed (Pianelli, 2007); (Pianelli, Saad and Abric, 2008). These groups were defined on the basis of their evocation or non-evocation of two main elements Pleasure and Danger. For the "Prudent" drivers, the representation of Speed is centred on Danger and Imprudence. This is the largest group in our population (N=441, 44% of the population). For the Defiant group (N=161, 16% of the population), the social representation of
Speed is based on the co-existence of the elements Danger and Pleasure. For the Hedonist group (N=122, 12% of the population), the representation of Speed is centred on its positive aspects: Pleasure, Rapidity and Gain of time. Lastly, for the Pragmatic group (N=281, 28% of the population), the speed is neither a pleasure nor a danger. For them, the representation of speed is centred on its functional aspects (Rapidity, Gain of time), but also on Speeding and Vigilance.

The social representations of Speed play an important role in the a priori acceptability of the LAVIA (Table 1). Prudent drivers accept more the LAVIA than the other groups and Hedonist drivers are the most opposite. It should be emphasised however that in each group a majority of drivers are hesitant towards the system.

Table 1. A priori acceptability of the LAVIA system for the four groups of drivers

<table>
<thead>
<tr>
<th></th>
<th>Prudent</th>
<th>Defiant</th>
<th>Hedonist</th>
<th>Pragmatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favourable (yes certainly)</td>
<td>37%</td>
<td>27%</td>
<td>23%</td>
<td>27%</td>
</tr>
<tr>
<td>Hesitant (yes may be)</td>
<td>44%</td>
<td>49%</td>
<td>46%</td>
<td>46%</td>
</tr>
<tr>
<td>Opposite (No)</td>
<td>19%</td>
<td>24%</td>
<td>31%</td>
<td>28%</td>
</tr>
</tbody>
</table>

4.1.2 After-use acceptability

After using the three LAVIA modes in real driving situations drivers indicated a clear preference for the Advisory mode compared to the two Active modes (Figure 2). Whatever the group of drivers, a large majority accept it after driving with it.

The acceptability of the Active modes decreased after they have been used in a real driving situations and the Mandatory active mode (the most restrictive one) is the least accepted mode, whichever group the driver belongs to. The acceptability of the systems after they have been used in real driving situations appears to be a function of the degree of constraint they impose on drivers’ activity, and of the behavioural adaptations they induce.

Figure 2. Driver’s acceptability of the LAVIA, before and after the experiment in real driving situation
4.2 Systems effectiveness as regards speed compliance

The selected itineraries, for data analysis purposes, represented 15,911 trips, or approximately 177 trips per vehicle, i.e. 3 a day, with average trip duration of 14 minutes and an average trip length of 8.3 kilometers. The greater part of the journeys took place in built-up areas (54.4%), and these areas are roughly associated with a speed limit of 50 kph (Table 2).

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>Without LAVIA</th>
<th>Advisory mode</th>
<th>Voluntary mode</th>
<th>Mandatory mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 km/h</td>
<td>29.2%</td>
<td>25.0%</td>
<td>22.1%</td>
<td>23.9%</td>
</tr>
<tr>
<td>40 km/h</td>
<td>35.4%</td>
<td>33.6%</td>
<td>28.2%</td>
<td>30.7%</td>
</tr>
<tr>
<td>45 km/h</td>
<td>32.3%</td>
<td>34.3%</td>
<td>23.2%</td>
<td>23.0%</td>
</tr>
<tr>
<td>50 km/h</td>
<td>12.9%</td>
<td>12.5%</td>
<td>10.5%</td>
<td>11.1%</td>
</tr>
<tr>
<td>60 km/h</td>
<td>29.1%</td>
<td>28.9%</td>
<td>23.6%</td>
<td>23.3%</td>
</tr>
<tr>
<td>70 km/h</td>
<td>28.3%</td>
<td>25.4%</td>
<td>14.9%</td>
<td>17.7%</td>
</tr>
<tr>
<td>80 km/h</td>
<td>34.5%</td>
<td>25.7%</td>
<td>23.9%</td>
<td>24.3%</td>
</tr>
<tr>
<td>90 km/h</td>
<td>19.9%</td>
<td>15.7%</td>
<td>12.7%</td>
<td>13.3%</td>
</tr>
<tr>
<td>100 km/h</td>
<td>13.5%</td>
<td>8.8%</td>
<td>5.7%</td>
<td>6.3%</td>
</tr>
<tr>
<td>110 km/h</td>
<td>4.8%</td>
<td>3.6%</td>
<td>4.8%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Total</td>
<td>16.5%</td>
<td>14.8%</td>
<td>11.9%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

The transition from neutral to Advisory mode engenders a drop of 1.7 points in time spent driving above the speed limits. This decrease moves to more than 4 points, between the active modes (voluntary and mandatory) and the neutral mode. The drop is more pronounced on road sections with more conventional posted speed limits: 30, 50, 90, 110 and 130 km/hr than on sections with transitional speed limits: 40, 45, 60, 70 and 80 km/h.

The gains in terms of narrowing speed limit excesses during transition from neutral to advisory mode are quite low especially on the urban network with a 50 km/h limitation. With the 50-km/h speed limit, the other two modes are effective, with an advantage for the voluntary active mode. On the other hand, for recommended speeds of more than 50 km/h, the gains become significant in the advisory mode, since the curves for this mode are higher than those for the neutral mode. The gains in the voluntary active and mandatory active modes are much higher than the ones in the advisory mode. At 90 kph, the fall in the average amount by which the speed limit was exceeded is 2.3 kph in the voluntary active mode and 2.2 kph in the mandatory active mode. The smaller gains in the mandatory active mode may be attributable to a greater use of the kick-down and to the fact that this use tends to take place on the urban network.
To sum up, there is a differentiation in the effectiveness of each LAVIA modes, with in general the Advisory mode being the least effective. The Voluntary active mode gives the best results in terms of reduction of excess speed with an average reduction of 2 km/h, under any types of network or speed limits. It is followed by the Mandatory active mode with an average reduction of 1.4 km/h, and in last position the Advisory mode with an average reduction of 0.8 km/h. Again the reduction is rather homogenous in absolute reduction under any types of network. In relative terms (reported to the speed limit), the higher is the speed limits, the greater is the reduction of speed deviations.

5. CONCLUSION

The aim of this paper was to present the overall evaluation process adopted in the LAVIA project. The main dimensions of the evaluation have been defined and the methodology used for assessing these dimensions has been presented. We have put an emphasis on the inter-dependencies and complementarities of the various methods used. Each phase of the evaluation process was seen as providing a specific insight on the various dimensions of interest, which have to be discussed and integrated along the evaluation process. The final step of the evaluation will consist in putting in perspective and weighing the various results obtained in order to formulate reasoned recommendations for future research and/or development strategies.

The results we have briefly presented, concerning drivers’ acceptability and system effectiveness illustrated and confirmed two important issues that, from our point of view, deserve further research: one is related to the levels and the dynamics of drivers’ acceptance of new support systems; the other one is related to the issue of finding the best compromise between systems’ effectiveness and their acceptability to drivers.

As a conclusion, we would point out that the result obtained so far represents one stage in the LAVIA evaluation process. The research now under way is aimed at deepening the analysis of drivers’ behaviour during the experiment, in particular by examining more precisely the impact of prior social representations and acceptability on system usage and speed behaviour; at getting a better understanding of the determinants of acceptability through a modelling approach designed to ascribe weightings to the respective shares of the different determinants.

REFERENCES


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