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Towards defining a unified concept for the acceptability of Intelligent Transport Systems (ITS): A conceptual analysis based on the case of Intelligent Speed Adaptation (ISA)

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Abstract

A key success factor in the future implementation of new in-vehicle technologies is in understanding how users will experience and respond to these devices. Although it is recognized that acceptance, acceptability and/or support is important, consistency in the definition of acceptability, and how it can be measured, is absent. In this paper we conceptualize acceptance as the attitudes towards a new device after its introduction and acceptability as the attitudes to it before its introduction. It is our goal to describe and conceptualize the most common and relevant socio-psychological factors that can influence acceptance and acceptability of Intelligent Speed Adaptation (ISA). By analysing the different theories and methods used in ISA trials we arrived at the 14 most potential indicators that could influence the definition of acceptability and acceptance. A test survey was conducted to determine if these indicators are relevant and if they affect acceptability. The use of a factor analysis helped to single out those questions that were deemed relevant in doing our conceptual acceptability analysis, and to allocate correlations between the different items. We conclude that we have found a concept with some main possible indicators that directly influence the acceptability of ISA.

Keywords

Acceptance, Acceptability, Driver attitudes, Intelligent Speed Adaptation, Support

1. Introduction

In their white paper "European Transport Policies for 2010: Time to Decide", the European Commission stated that the main challenges for sustainable mobility include a reduction of congestion, an increase in traffic safety (a 50% reduction in fatalities in 2010 compared with 2000), an increase in energy efficiency, and a reduction of dependence on fossil fuels (European Commission, 2001). The use of different transport technologies (also known as Intelligent Transport Systems or ITS) may play a significant role in achieving these policy goals. Many ITS applications in the field of traffic management and travel information that are already on the market have proved their effectiveness. These systems support transport system users, traffic managers, and fleet operators with traffic and travel information. However, to achieve the stated EC transport policy goals, the implementation of more advanced ITS applications is required, with active intervention in vehicle driving tasks. This category of ITS device is also known as the Advanced Driving Assistance Systems (ADAS) that partially take over driving tasks such as distance keeping, lane keeping, overtaking, and so on. Many research initiatives on different ADAS technologies are being conducted at international, national, and regional level. While most studies focus on the technological feasibility of ADAS and its intended impacts, an important question as to whether these new technologies will be accepted and used remains unanswered.

ADAS vary from relatively simple systems that provide drivers with basic information to relatively complex systems that take over parts of the drivers' tasks to achieve 'good' driving behaviour (Brookhuis & De Waard, 2005). The need to understand how users experience and respond – or not – to the support of ADAS is important for determining how drivers' needs can be integrated into the development and implementation of ADAS. In general, understanding potential users' points of view has been roughly noted as acceptance or acceptability. Although several studies have examined acceptance and/or acceptability of ADAS there is little consistency on what is understood by acceptance or acceptability and, equally important, how these factors can be measured (cf. Molin & Brookhuis, 2007). The present paper aims to define acceptance and acceptability, and to determine which indicators should be considered relevant for their measurement. Our application involves Intelligent Speed

Adaptation (ISA). ISA is a traffic safety device that warns the driver about speeding, discourages the driver from speeding, or prevents the driver from exceeding the speed limit (Brookhuis & De Waard, 1999), and hence, can be considered an ADAS application.

The aim of this paper is first to define acceptance and acceptability, i.e. to develop a theoretical framework that concurs with our conceptualization. We introduce our definitions of acceptance and acceptability, and give a brief overview of current theories and methods used in ISA trials. Based on these theories and methods we then define similarities between the items or determinants that lead to the selected indicators. In section 3 we outline a conceptual framework. This framework forms the basis for constructing a test survey to discover which indicators can be considered relevant, and if they are, what correlations exist between the described indicators. In section 4 we describe the research method used for the test survey. In section 5 we summarize the results of our test survey based on factor analysis. In the final section we set out our conclusions and propose avenues for future research.

2. Defining acceptance and acceptability in ITS and ISA research

2.1 What is acceptance and acceptability?

Acceptance, acceptability, social acceptance, public support, social support, etc. are all terms frequently used to describe a similar phenomenon, how potential users will react and act if a certain measure or device is implemented. The interest in defining acceptance or acceptability lies in the precondition that the effectiveness and success of a measure will increase if there is public/social support for it. Under favourable conditions a positive assessment leads to an increased willingness to accept a measure and even to support it actively (Nelissen & Bartels, 1998; Goldenbeld, 2002). Although it is recognized that acceptance, acceptability, and support are important, a clear definition of what acceptance and acceptability are and precisely how they should be measured is still absent (Adell, 2008a; Regan et al., 2006; Vlassenroot, 2006).

To a certain extent the terms acceptance and support are strongly related. Goldenbeld (2002), however, introduces an important nuance between both concepts. The basic idea is that even if acceptance exists, it would not necessarily lead to the support of a measure.

In the field of ITS, Ausserer and Risser (2005) define acceptance as a phenomenon that reflects to what extent potential users are willing to use a certain system. Hence, acceptance is linked closely to usage, and acceptance will depend on how user needs are integrated into the development of the system. Nielsen (cited in Young et al., 2003) described acceptability as related to the question of whether the system is good enough to satisfy all the needs and requirements of the users and other potential stakeholders. More generally, in Rogers' (2003) diffusion of innovations, acceptability research is defined as the investigation of perceived attributes of an ideal innovation in order to guide research and development to create such an innovation. Van der Laan et al. (1997) distinguished between user acceptance and social acceptance. User acceptance is directed more towards evaluation of the ergonomics of the system while social acceptance is a more indirect evaluation of consequences of the system.

In another distinction between acceptance and acceptability, Schade and Schlag (2003) described acceptance as the respondents' attitudes, including their behavioural responses, after the introduction of a measure, and acceptability as the prospective judgement before such future introduction. In this case, the respondents will not have experienced any of the measures or devices in practice, which makes acceptability a construction of attitude. In our research, we are more interested in defining the social aspects that could lead to public acceptability. Our research target group will not have experienced driving with ISA. Therefore, the term acceptability should be preferred, whereas in the literature this difference is not always found.

The lack of a theory and definition regarding acceptance has resulted in a large number of different attempts to measure ITS acceptance, often with quite different results (Adell, 2008a). Some existing theories were used to measure these within the acceptance and acceptability research of ITS. In the next sections we describe some of the 'general' user acceptance models, acceptability theories, and research into ISA.

2.1 User acceptance models and theories

One of the most frequently used frameworks to define acceptance is the Theory of Planned Behaviour (TPB). Based on the Theory of Reasoned Action (Fischbein & Ajzen, 1975), the TPB assumes that behavioural intentions, and therefore behaviour, may be predicted by three components (Van Acker et al., 2007, 2010): attitudes towards the behaviour, which are individuals' evaluation of performing a particular behaviour; subjective norms, which describe the perception of other people's beliefs; and perceived behavioural control, which refers to people's perception of their own capability.

TPB has been used successfully to predict behaviour in a wide variety of applied research settings within different domains, including several studies dealing with driving behaviour and traffic safety, such as the effects of drinking and driving (Aberg, 1993; Parker et al., 1992a), driving violations (Parker et al., 1992b), and speeding and speed behaviour (Elliot et al., 2005; Haglund et al., 2000). Warner and Aberg (2006) specifically used the TPB related to the use of ISA. Comparing self-reported speeding of test drivers within an ISA trial with logged data explained 28% of the variance in logged speeding. In their study, Warner and Aberg (2006) noted that perceived behavioural control did not add significantly to the prediction of drivers' logged speed.

Another successful model is the Technology Acceptance Model (TAM) (Davis et al., 1989). TAM was designed to predict information technology acceptance and usage on the job. TAM assumes that perceived usefulness and perceived ease of use determine an individual's intention to use a system with the intention to use serving as a mediator of actual system use. TAM has been used – in the field of ITS – in the prediction of electronic toll collection (Chen et al., 2007).

Van der Laan et al. (1996) published a simple method to define acceptance. Acceptance is measured by direct attitudes towards a system and provides a system evaluation in two dimensions. The technique consists of nine rating-scale items. These items are mapped on two scales, the one denoting the usefulness of the system, and the other satisfaction.

Venkatesh et al. (2003) noted that there are several theories and models of user acceptance of information technology, which presents researchers with difficulties in choosing the proper model. Venkatesh et al. (2003) found different underlying basic concepts in acceptance models by means of a detailed description and analysis of different models such as TPB, the motivational model, TAM, innovation diffusion theory, and combined models. Based on these theories, they constructed a unified model they named the Unified Theory of Acceptance and Use of Technology (UTAUT). In the UTAUT, four constructs play a significant role as direct determinants of user acceptance: (i) performance expectancy – the degree to which an individual believes that using the system would help him or her to attain gains in job performance; (ii) effort expectancy – the degree of convenience with the use of the system; (iii) social influence – the importance of other people's beliefs when an individual uses the system; and (iv) facilitating conditions – how an individual believes that an organizational and technical infrastructure exists to support use of the system. The supposed key moderators within this framework are gender, age, voluntariness of use, and experience. Although in several models, 'attitude towards use', 'intrinsic motivations', or 'attitude towards behaviour' are the most significant determinants of intention, these are not mentioned in the UTAUT. Venkatesh et al. (2003) presumed that attitudes towards using the technology would not have a significant influence.

Stern (2000) developed the value–belief–norm (VBN) theory to examine which factors are related to acceptability of energy policies. Stern and colleagues proposed the VBN theory of environmentalism to explain environmental behaviour, including the acceptability of public policies. They proposed that environmental behaviour results from personal norms, that is, a feeling of moral obligation to act pro-environmentally. These personal norms are activated by beliefs that environmental conditions threaten the individual values (awareness of consequences) and beliefs that the individual can adopt to reduce this threat (ascription of responsibility). VBN theory (Steg et al., 2005) proposes that these beliefs are dependent on general beliefs on human–environment relations and on relatively stable value orientations. VBN theory was successful in explaining various environmental behaviours, among which consumer behaviour, environmental citizenship, willingness

to sacrifice, and willingness to reduce car use (Stern et al., 1999; Nordlund & Garvill, 2003).

Schlag and Teubel (1997) defined the following essential issues determining acceptability about traffic measures: problem perception, important aims, mobility-related social norms, knowledge about options, perceived effectiveness and efficiency of the proposed measures, equity (personal outcome expectation), attribution of responsibility, and socio-economic factors.

2.2 Acceptance measurements in ISA trials

In our approach we want to describe the most common and relevant socio-psychological factors that influence acceptance and acceptability of ITS and actively interact with vehicle driving tasks. We will focus on ISA. ISA can be categorized within different types, depending upon how interventionist (or permissive) they are (Morsink et al., 2006).

[Insert Table 1. Overview of different types of ISA (Morsink et al., 2006)]

In most ISA studies, acceptance and acceptability refer to the opinions, attitudes, and values of the users relative to the experience they had when driving with the system (Brookhuis & De Waard, 1999; Comte et al., 2000; Vlassenroot et al., 2007; Young & Regan, 2007). In these studies, acceptance is measured by comparing behavioural changes when driving without ISA before using the device and driving with ISA and finally driving without ISA after the test period (Adell et al., 2008; Biding & Lind, 2002; Hjalmdahl & Varhelyi, 2004; Katteler, 2005). Brookhuis and De Waard (1999) defined these behavioural changes as the level of adaptation instead of acceptance. Adaptations are those behaviours that may occur following the introduction of changes to the road-vehicle user (Dragutinovic et al., 2005). Therefore, adaptation will better describe the behavioural outcomes (and changes) when drivers have experienced the device, while acceptance will be more related to

the attitudes, norms, and beliefs that may influence adaptation. Goldenbeld (2002) has noted that opinion and attitude studies are the most widely adopted research methods for measuring acceptability and acceptance of road safety measures.

Based on recent ISA field trials in different countries, certain directions for defining acceptance can be found. Although the main research set-ups and methods used were different in most trials, some common ground is evident.

In a large-scale ISA trial in Sweden, different types of ISA were tested voluntarily by 10,000 drivers between 1999 and 2002 (Biding & Lind, 2002). In these trials, acceptance was measured by relating attitudes to traffic safety and speed with experience of the tested ISA, willingness to pay, performance when using ISA, and the Van der Laan scale.

In the Dutch ISA trial (Ministerie van Verkeer en Waterstaat: Adviesdienst Verkeer en Vervoer, 2001) a mandatory (closed) system was tested, implying that the drivers could not violate the speed limit. The acceptance aspect focused primarily on the influence of ISA on drivers' tasks (e.g. driving behaviour inside and outside the limited areas), technical functions of ISA, and ergonomic issues.

In the Australian trial (Regan et al., 2006), the acceptance study was based on the model of Davis and Nielsen (cited in Young et al., 2007). The five main constructs were usefulness (users perceive the system to serve a purpose), effectiveness (users believe that the system does what it is designed to achieve), usability (the ease of use of the system), affordability (willingness to pay), and social acceptability (broader scale that users may take into account in assessing whether ISA is acceptable). The scope of research in the Australian trial involved other ITS devices such distance-keeping warning.

In 2001, a new trial started in the UK, called ISA-UK (Carsten et al., 2008). In four field trials conducted in different parts of the UK, 80 private and professional test drivers drove 20 vehicles that had a system installed over a period of six months (during the first and last month the system was not activated). The system made it impossible for the test drivers to exceed the speed limits without using kick-down or pressing an emergency button. Predicting speeding behaviour and drivers' attitudes was assessed by using TPB related to speeding in three scenarios: speeding on a

motorway, urban 40 mph road, and residential 30 mph road. The impact of ISA on acceptance was rated using dimensions of usefulness and satisfaction.

In 2004 an ISA experiment with 20 vehicles was conducted near Versailles, France (Pianelli et al., 2007). A survey was carried out to study the drivers' acceptance of the system and to define both their attitudes and social representations of speed and ISA. This means that the behaviour of individuals and groups is directly determined by the responses they show for an objective or to the situation in which they find themselves. Social representations guide relationships, communications, and social practices.

In a Belgian trial (Vlassenroot et al., 2007), drivers drove with an active accelerator pedal, implying that the drivers received feedback through a push-back of the accelerator if they sped. The concept of acceptance was based on a framework designed to define public opinions on speed measures and ISA. This framework denotes how people view mobility and transportation in relation to road safety, especially with respect to speed, speeding, and speeding restrictions. Based on this framework, basic attitudes to road safety, speed, and speeding, and recognition of speed as a problem in society and attitudes about road safety and policy could be measured, distinguishing between different socio-demographic backgrounds of transport users. Further aspects were the voluntary use of the system outside the test area, willingness to pay, and the scaling of the use of ISA on satisfaction and usefulness (Van der Laan et al., 1997).

A Danish trial (Harms et al., 2007) used an open ISA system, based only on information about speeding, in combination with other incentives when driving safely (e.g. lower insurance premiums). This trial focused on the influence of background factors such as age and driving experience, questions related to driving style, attitudes to safe driving, driving speed and speed limits, and to risky traffic behaviour. The respondents were also asked to judge a number of frequently used ISA features, and to anticipate effects of driving with ISA.

Molin and Brookhuis (2007) defined problem awareness, car drivers' beliefs about the selected policy instruments, and car drivers' personal characteristics as the main variables that would influence ISA acceptability. De Mol et al. (2001) based

ISA acceptability measurement on the attitudes and opinions given by individuals, which stand for the general public. Within this concept several layers with mutual relations were defined, with the socio-demographic issues and the individual transportation habits as the 'basic' factors for the creation of public support. The basic attitudes denote how people perceive mobility and transportation, in particular the perception of speed in relation to motorized vehicles. Public support is also determined by 'being a (problem) issue in society', because, if there is no social indication that a problem about the relationship between road safety, speed, and speeding is perceived, there will be no change in future acceptance. Some of the abstract norms and values are made concrete in issues concerning how people think about road-safety measures. At this level a 'real' discussion on possible acceptance should occur. Within the SARTRE (Social Attitudes to Road Traffic Risk in Europe) project (Drevet, 2004) some questions related to how people noticed speed and speeding, and were brought into relation with willingness to use a speed-limiting device. Some of the aspects used in acceptance research and in acceptability research are mutual.

As a reminder, we will define acceptance as the reaction (beliefs and attitudes) of individuals, based on their behavioural reactions *after the introduction* of a measure or device. Acceptability describes the prospective judgement of measures *to be introduced* in the future. In our further research we will focus on acceptability instead of acceptance.

3. Conceptualization of the model

The previous sections described how methods and theories are used to distil the most relevant determinants that could influence acceptance and acceptability. In these theories and methods we tried to find which items were related to each other. Venkatesh et al. (2003) did a similar exercise to build their UTAUT model. Table 2 gives an overview of some of the theories used to select the indicators.

[Insert Table 2. Examples of theories used to select the indicators]

In Figure 1 a distinction is made between general indicators (related to the context awareness of the system) and system-specific indicators (directly related to the characteristics of the device). The 14 indicators are considered to be the most relevant that can or will influence acceptance/acceptability. These general and specific indications will influence each other and the level of acceptance and acceptability. We give a brief description of every indicator.

[Insert Figure 1. General and system specific indicators that can influence acceptance or acceptability]

3.1 General indicators

Individual factors

Gender, age, level of education, and (income) employment are considered to influence how people think about speed and speeding and therefore on the use of ISA. Gender and age are considered as relevant determinants within the performance of speeding behaviour. Speed is more associated with young drivers (Ingram et al., 2001; Parker et al., 1992a; Stradling et al., 2000), and more specifically, with young male drivers (Stradling et al., 2003). Although male drivers are more likely to speed, some studies noted that a difference between sexes could not be found. Shinar et al. (2001) analysed the proportion of licensed drivers that reported that they drive within the speed limits. They noted that age, education, income, and gender are relevant factors in speeding behaviour. Shinar et al. (2001) observed that drivers who were more educated and had a higher income (related to employment) were more likely to report that they sped than the less educated and poorer respondents.

Attitudes to driving behaviour and speeding/traffic safety

Travel behaviour, driving style and the choice of vehicle are also related to speeding behaviour. Silcock et al. (2000) noted that people admitted to driving faster in more powerful and comfortable cars. Moreover, Steg et al. (2001) conducted a study to clarify the importance of symbolic-affective as opposed to instrumental-

reasoned motives for car use. These motives for car use can have an impact on why individuals drive too fast, or whether they would or would not accept ISA. Stradling et al. (2003) examined the demographic and driving characteristics of speeding, violating, and thrill-seeking drivers. They concluded that in England drivers who speed, who violate other rules of the road, and who seek excitement when driving, pose greater risks to themselves and to other road users. Stradling et al. (2003) also found two population groups whose driving behaviour put themselves and other road users at risk. The first group was young and mostly, but not exclusively, male drivers. The second group was drivers from high-income households, living out of town, driving larger-engine cars for high annual mileage as part of their work. Crash involvement has been noted as a possible influence on speed and speeding behaviour. In relation to defining the acceptance and acceptability of ISA, the influence of travel behaviour, car use, vehicle choice, and driving style should be considered relevant indicators.

Personal and social aims

Schade and Schlag (2003) describe personal and social aims as the dilemma between social or personal aims and benefits. They assume that a higher valuation of common social aims will be positively related to acceptability. Clearly, people who want to drive as fast as possible will have a lower acceptability and acceptance of ISA. Another issue is the effect of speeding measures on individual freedom. Policies or devices that seriously affect individual freedom will be less acceptable (De Groot & Steg, 2006).

Social norms

Perceived social norms and perceived social pressure refer to the (assumed) opinions of their peers multiplied by the importance of the others' opinions for the individual. In other words, social norms refer to an individual's assumptions about whether peers would think that he or she should accept the device (Ajzen, 2002; Schade & Schlag, 2003). It is assumed that peers, e.g. co-workers or specific other road users, will influence the attitudes and behaviour of individuals

Problem perception

The extent to which speeding is perceived as a problem is a necessary indication in defining acceptance and acceptability. There is common agreement that high problem awareness will lead to increased willingness to accept solutions for the perceived problems (Schade & Schlag, 2003; Steg et al., 1995; Eriksson et al. 2006; Goldenbeld, 2002; Molin & Brookhuis, 2007; De Mol et al., 2001).

Responsibility awareness

This concept is based on the norm activation theory (Schwartz, 1977) and environmental travel demand management studies (Eriksson, 2006; Steg & De Groot, 2006; Stern, 2000). Responsibility awareness explains how an individual stands in respect to the issue of whether it is the government (others/extrinsic) or the individual (own/intrinsic) that is deemed to be responsible. It is assumed that environment-preserving behaviour becomes more likely if individuals perceive the damaging consequences of their own actions on the environment and others, and at the same time ascribe the responsibility for the consequences to themselves (Schade & Schlag, 2003).

Information and knowledge about the problem

The level of acceptability can depend on how well-informed the respondents are about the problem and about any new device that is to be introduced to solve the problem (Schlag & Schade, 2003; Steg et al., 1995). The hypothesis may be that the more that people are informed, the higher the acceptance/acceptability will be. However, better knowledge about a problem can also lead to less acceptance/acceptability for a specific solution caused by, for instance, awareness of alternatives to solve the problem.

3.2 Device-specific indicators

Device-specific beliefs are directly related to the characteristics of the system. Seven indicators could have the potential to define acceptance or acceptability and how user needs are integrated into the system. As noted, ISA acceptance is related to

drivers' attitudes and behaviour about speed and speeding. Therefore, the previously noted concepts of general beliefs must be taken into consideration and will influence specific beliefs for defining acceptability of ISA.

Perceived efficiency

Perceived efficiency indicates the possible benefits users expect of a concrete measure (or device) as compared with other measures.

Perceived effectiveness

Effectiveness refers to the system's functioning according to its design specifications, or in the manner it was intended to function (Young et al., 2003). In most ISA trials, this was found through an evaluation of the technical/ergonomic issues. The main question in these trials remained whether the system assisted the driver to maintain the proper speed. The level of effectiveness can depend on how interventionist a system is or was. For instance, an advisory system can be considered as less effective than a system that prevents the driver from exceeding the speed limit.

Perceived usability

Perceived usability is the ability to use the system successfully and with minimal effort. Usability is also an indication for how users understand how the system works. User friendliness can be associated with usability: the users will expect a service that does not distract or overload them with information and (difficult) tasks (Landwehr et al., 2005).

Perceived usefulness

Perceived usefulness is related to how the system supports the drivers' tasks and driving behaviour. Usefulness is, in a certain way, different from effectiveness. A potential user can find ISA effective in general but not for his own driving behaviour. Young et al. (2003) define usefulness as the degree to which a person believes that using a particular system will enhance his or her performance.

Satisfaction

Satisfaction is one of two factors derived form the items within the ITS acceptance scale that Van der Laan et al. (1997) developed to study user acceptance.

Equity

In general, equity refers to the distribution of costs and benefits among affected parties. However, from a psychological viewpoint, perceived justice, integrity, privacy, etc., are basic requirements for acceptability. This may differ from the objective costs and benefits, but equity is an important indicator influencing personal perceptions (Schade & Schlag, 2003). The integrity of driver information, privacy, and loss of certain freedom in driving can be an issue for willingness to use ISA.

Affordability

It may be assumed that socio-economic status will affect acceptance and acceptability, as users will consider ISA as a symbol of status ('having ISA as a new gadget or feature'), or they will want to be among the early adopters (Rogers, 2003). On the other hand, affordability will depend on the individual's budget and/or public/private funding. It is to be expected that low-income groups will be more opposed to ISA. In many trials acceptance was defined by willingness to pay for ISA (Vlassenroot et al., 2007; Biding & Lind, 2002; Hjalmdahl, 2004). The willingness to pay will depend on income, but in many trials it is assumed that the more people are willing to pay, the higher the acceptance and acceptability will be. Incentives such as lower road taxes and lower insurance fees can stimulate the acceptance or acceptability of ISA (Lahrmann et al., 2007; Schuitema & Steg, 2008).

4. Research methodology

In the previous section we described the most relevant indicators that could influence acceptance and acceptability based on previous research and methods. In this section we want to develop our conceptual framework operational. To this end, we developed and tested a first survey.

4.1 Survey set-up

Based on the literature about acceptance and acceptability theories and models, different factors and some 250 possible questions from past surveys – some questions had multiple sub-questions – were found. These questions were categorized into questions about (i) personality characteristics, (ii) problem recognition related to speed and speeding, (iii) the use and integration of the actual methods to counter speeding, and (iv) the use of the new technology (ISA) to counter speed and speeding. These clusters made it possible to identify similar questions and to redefine some questions. The above-mentioned 14 indicators were also positioned in these clusters.

In the second phase only questions relevant to defining the indicators were withheld: about 60 questions were deemed relevant. A first survey was made, based on these questions. Some of the questions were redefined and only the most relevant questions were taken into account. The number of main questions was reduced to 36, most of which consisted of different items (sub-questions) that had to be rated (besides some identification questions) on a 5-point Likert-scale. To reduce the number of items that the respondents had to fill in, in questions relating to car choice and responsibility awareness, respondents were asked to rank the items from most important to least important.

A Web survey was assembled using the open source program ‘Limesurvey’ and sent first to colleagues for testing. Using their comments, especially about user friendliness, a pilot test survey was made and circulated by mail and the popular networking site Facebook. The goal was to reach 150 respondents. Based on the answers of these respondents some modifications were made to improve the survey

and some of the early responses were processed to find out if the questions would cover the described indicators (main variables).

Finally the definitive Web survey was published online. The goal was to have at least 1000 respondents in Belgium (Dutch-speaking part) and 1000 respondents in The Netherlands. The Web address of the survey was distributed by the Flemish and Dutch motoring organizations. In Flanders a motoring organization sent an email newsletter to their members, in the Netherlands, the link to the survey was announced on motoring organization's website.

The same survey will be given to certain stakeholders involved in transport policy and ITS deployment, who will be asked to estimate how people would answer the questions.

4.2 Data analysis

While we used factor analysis in our analysis of the pilot test-survey data, we are aware that this approach has some limitations. For instance, the analysis depends very much on researchers' interpretation of results. However, the goal of this analysis is to find some first indications and relationships to define our concept of acceptability. Second, factor scores provide a means to summarize information on a large number of variables in a manageable and meaningful form.

5. Primary results from the pilot test survey

In total 217 individuals responded to the questionnaire, but only 148 respondents completed the survey. The answers of these 148 respondents were analysed. Factor analysis was used to investigate if the questions and sub-questions (see Table 3) covered the pre-defined indicators and if some other (internal) relations could be found. Some of the indicators consisted of different items, which covered a series of sub-questions (e.g. the indicator of problem perception consisted of items such as accident influence, attitudes about speeding, etc). These sub-questions will be reduced to factors that cover the items within the indicator or main variable.

The indicators of ‘individual factors’, ‘travel behaviour’, ‘driving style, and car use’ are not given in the first analysis. Questions relating to usability were not asked as the respondents had not experienced the system and it was difficult to predict how the Human–Machine Interface (HMI) would be developed in the future. The ‘responsibility awareness’ indicator was asked in the survey but could not be processed in the factor analysis because of a wrong question set-up in the survey. In the future survey this indicator will be asked differently (on a Likert-scale instead of ranking).

5.1 Factor analysis

In general our questions covered every indicator that we intended to ask in the large survey (see Table 3). Factor analysis is made per indicator or item. Most of the indicators or items within the indicators loaded onto one factor. Some of the most relevant ones are described below.

[Insert Table 3. Factor loadings for the pre-defined indicators and (sub)-items]

Problem perception

The extent to which speeding was perceived as a problem is a necessary indicator for defining acceptance and acceptability. Four items were considered relevant in defining perception of this problem: (i) what will cause accidents, (ii) attitudes to speed and speeding, (iii) insecurity feelings when speeding, and (iv) opinions about posted speed limits.

Noteworthy is that 58.2% of the variance is explained by three factors regarding causes of accidents. Speeding and driving under the influence of alcohol and drugs are loaded onto the same factor. Speeding, alcohol, and drugs are considered to be the main issues in accident risks. For factor 2, more ‘indirect issues’, such as no experience as a driver, infrastructure, and inexperienced other drivers, are

loaded. On factor 1 other recognized issues that can cause accidents, such as thrill-seeking behaviour, poor distance keeping, fatigue, and weather conditions, are loaded.

On the attitudes to speed and speeding, some issues are loaded onto a factor that would explain the relationship between traffic safety and speeding (danger and safety) and a factor that would explain the emotional experience and perception of speeding (fun, excitement, and freedom).

Three factors related to the feeling of insecurity about whether inappropriate speed is noticed are found. It is noted that almost every time the problem of speeding in lower speed areas such as school environments and residential zones are loaded onto one factor (factor 2). We may assume that driving too fast in these areas is almost unforgivable for our respondents. On the other hand, it could be that when asked about speeding in these areas, people would be better able to imagine school and residential surroundings than when asked about urban or non-urban zones.

Personal and social aims and social norms

Clearly, people who want to drive as fast as possible according to their own preferences will have a lower acceptability and acceptance of ISA.

For this indicator it was difficult to find relevant questions that are related to personal and social aims when speeding. Therefore the 'personal and social aims' are put into different kind of situations. Through this factor analysis we may conclude that these items are relevant.

Perceived social norms and perceived social pressure refer to the assumed opinions of peers. Our survey attempted to assess peer pressure relative to speed and speeding.

Effectiveness and efficiency

In most ISA trials this was done through an evaluation of the technical/ergonomic issues. The main question in these trials remained whether the system supported the driver to maintain the legal speed. Almost every item about 'finding a measure effective to counter speed' was loaded onto one factor. In-vehicle technology was loaded onto factor 2. We assume that because in-vehicle technology

was not yet available the respondents would value this in a different way than the other measures. Campaigns had a negative loading (-0.48) on the second factor.

Usefulness

Perceived usefulness is related to how the system will support the drivers' tasks and driving behaviour. In our questionnaire we compared the ISA system with other ITS and used the usefulness items from the van der Laan scale. Four factors were distinguished when we asked about the usefulness of different ITS systems. Factor 3 was mainly related to perceived feelings of freedom and privacy, such as closed and supportive ISA (less individual control of speed and speeding) and the black box (which can monitor driving behaviour). Collision warning, active cruise control, and distance warning systems were loaded highest onto the same factor (factor 2). ITS systems related to avoiding an accident were found together. On factor one, systems were found that prevent the driver from starting. It seems also that open and warning ISAs are found on one factor (systems related to speeding behaviour), except for those ISA systems that could be considered as reducing the feeling of freedom in driving.

Usefulness and satisfaction (van der Laan-scale items)

As described above, usefulness and satisfaction are considered important items for defining acceptance. Our acceptability research also investigated these items with a view to evaluating an informative warning and supportive system. The results indicated a good relation between the items of satisfaction and usefulness.

Equity and affordability

To define equity, the respondents had to indicate when they would use a certain system. The choices they had, were: (1) never, (2) if 90% or more of every vehicle was equipped, (3) if 60% of every vehicle was equipped, (4) if 30% of every vehicle was equipped, (5) if 10% or less of every vehicle was equipped. Affordability was rated on a scale from 1 to 5 (from 1 = I want to buy it, 3 = need of incentives, 5 = I never want to buy it). In addition, one factor was found for the equity items and one for the affordability items.

5.2 Correlations between factors

In Table 4 the correlations between the different factors are given. Only the highest and most significant correlations per item are described (instead of factors). These 'raw' data could give a first indication of whether there are relations between the 14 indicators.

[Insert Table 4. Correlations between different items and indicators based on results of the pilot survey]

A low correlation was found between almost all general indications and between the device-specific indications. Strong correlations were found (R^2 more than 0.80) between the van der Laan items' usefulness and satisfaction. Generally, we can conclude that the items are relevant for defining the acceptability of ISA.

A moderate level of correlation was found between the items 'accident influence' and 'opinions about measures to counter speed', 'attitudes about speed and speeding and speed limits' and 'attitudes about speed and speeding' and 'personal and social aims'. This was the only moderately significant correlation between 'personal and social aims' and some items of 'problem perception'.

Only low levels of correlation were found between 'social norms' and some items of 'problem perception', 'personal and social aims', and the 'usefulness' item about ITS. The indicator of effectiveness and efficiency also had a moderate correlation with the usefulness and satisfaction items of a supportive system and with relative equity. The equity item when ISA was installed correlated well with affordability. Moderate levels of correlation were found between the acceptability of ISA and ISA effectiveness, ITS usefulness, usefulness of informative system, and equity. A marked correlation is found between acceptability and usefulness and satisfaction of a supportive system.

In future research based on large-scale survey results, this model should be re-estimated, allowing more relevant relations to be found.

6. Conclusions

It is recognized that knowledge concerning the level of acceptance or acceptability of a measure is important for future implementation of in-vehicle technologies. Ironically, a clear definition of what acceptance and acceptability are or how they should be measured is still lacking. In this paper we aimed to improve on this lack of knowledge. We made a distinction between acceptance and acceptability based on time and experience of the individual, whereby acceptance entails beliefs and attitudes, based on their behavioural reactions after the introduction of a measure. Acceptability describes the prospective judgement, based on attitudes and beliefs about a measure, without experience, to be introduced in the future.

New vehicle technologies such as ISA are difficult to implement. Therefore there is a need to understand which factor or indicator would influence future drivers' acceptability or acceptance. Based on different socio-psychological theories and methods used in ISA trials we found 14 relevant indicators that we divided into general indicators (related to persons' psyches, social values and norms at that time, and so on) and device-specific indications (factors that are directly related to the device itself). These 14 indicators were presented to randomly selected respondents (through new Internet media) in a test survey. The main goal of this survey was to find if the distilled indications and the questions were relevant, and if some relations could be found between the indicators . Through the use of factor analysis we found out that our questions were relevant for every item and some correlations were found between the items. It is also noted that some indicators would directly influence the acceptability of ISA while some would influence others more indirectly. This first step in our research enabled us to conduct a relevant large-scale survey among the general public in The Netherlands and Belgium on the acceptability of ISA.

In the second phase of our research analysis, following the large-scale survey, the data will be processed to define how indicators relate to each other and how they fit the model. This model will be used to define how far implementation strategies should be taken to encourage higher acceptability and future acceptance of ISA. Some cross-cultural research will also be done and the answers related to answers given by different stakeholders.

One of the key issues is how the public will react if ITS is implemented. The understanding of the defined indications that will influence acceptability and acceptance may support decision-makers in developing an appropriate implementation strategy. Through the construction of this framework, we want to provide decision-makers with methods and procedures that are easy to use and understand, based on well-accepted socio-psychological models.

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Figure(s)
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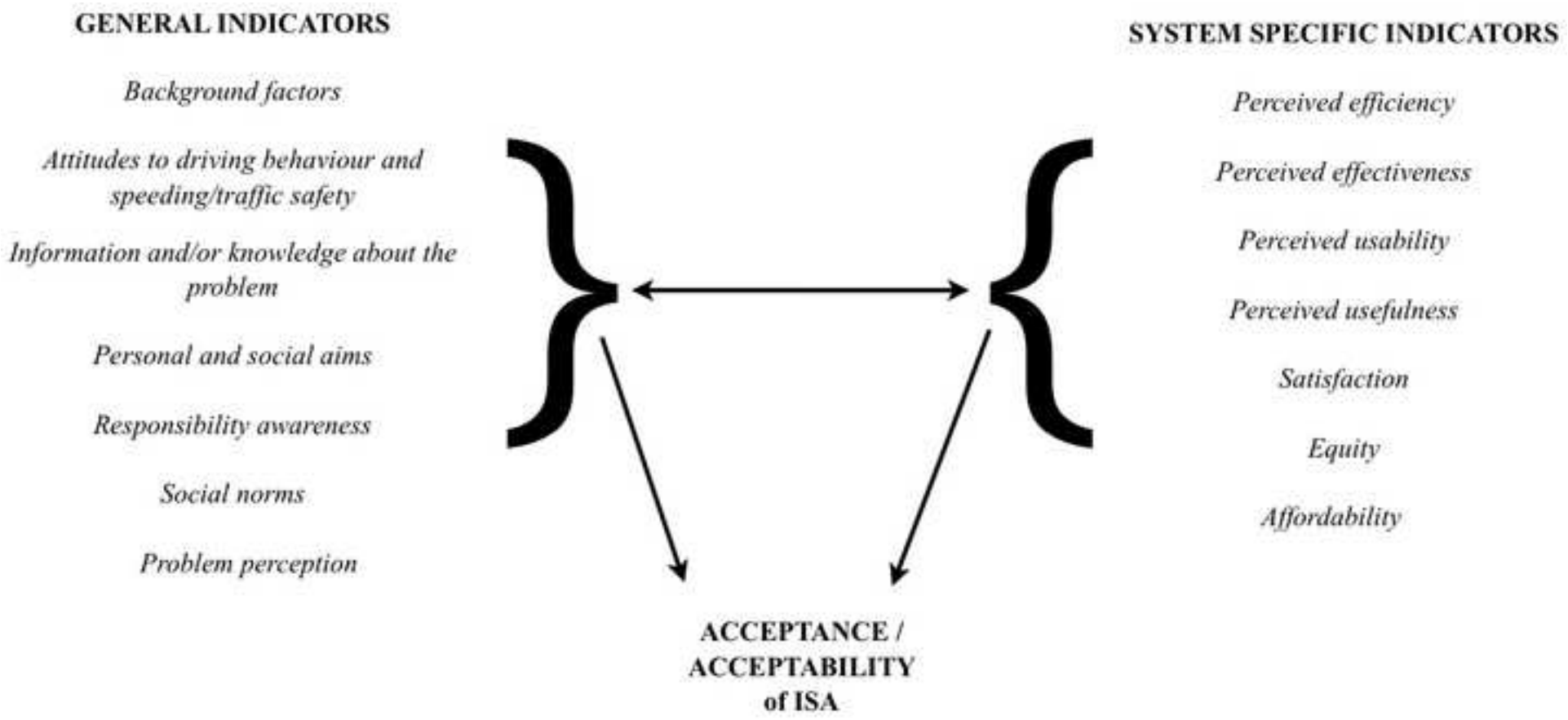

Table(s)

Table 1. Overview of different types of ISA (Morsink et al., 2006)

Level of Support	Type of feedback	Definition
Informing (open)	Visual	The speed limit is displayed and the driver is reminded of changes in the speed limit.
Warning (open)	Visual/auditory	The system warns the driver when exceeding the posted speed limit at a given location. The driver decides whether to use or ignore the information or warning.
Assisting (half-open)	Haptic throttle	The driver gets a force feedback through the gas pedal if he/she tries to exceed the speed limit. Overruling of the system is still possible
Restricting (closed)	Dead throttle	The speed of the vehicle is automatically limited and the driver can not overrule the system.

Table(s)

Table 2. Examples of theories used to select the indicators.

		Attitudes to driving behaviour and traffic safety	social norms	Perceived Efficiency	Perceived usefulness	Perceived usability	Individual factors		Experience or/and knowledge	Equity	Satisfaction	Affordability	Perceived effectiveness	Problem perception	Personal and social aims	Responsibility awareness
Acceptance models	TPB (Azjen, 2002)	Attitude towards behaviour	Subjective Norm	Perceived Behavioral Control												
	TAM (Davis et al. 1989)		Subjective Norm		Perceived Usefulness	Perceived Ease of use										
	UTAUT (Venkatesh, 2003)		Social Influence	Facilitating Conditions	Performance Expectancy	Effort Expectancy	Gender	Age	Experience	Voluntariness of use						
	Van der laan scale (Van de Laan et al. 1994)				Usefulness						satisfaction					
Acceptability models	Schade & Schlag (2003)		Social Norms				socio-economic factors		Knowledge	Equity			Perceived effectiveness	Problem perception	personal aims to reach	Responsability
	VBN theory (Stern 2000)	Values							Ecological worldview				Awareness of consequences		personal norms	Ascription of resonsinility
ISA research acceptance	Sweden (Biding & Lind, 2002)	Attitudes to traffic safety			Usefulness				Experience		satisfaction	wilingness to pay				
	The netherlands (Ministerie van Verkeer en Waterstaat: Adviesdienst Verkeer en Vervoer; 2001)				drivers' tasks	ergonomics										
	Australia (Regan et al., 2006),			social acceptability	Usefulness	usability						affordability	effectiveness			
	France (Pianelli et al., 2007)	Social Representations				ease of use										
	Belgium (Vlassenroot et al., 2007)	Attitudes to safety		efficiency	Usefulness		socio-demographic backgrounds				satisfaction	willingness to pay		problem awareness		
	Denmark (Harms et al., 2007)	attitudes to safe driving				judgement on ISA features	background factors									
ISA research acceptability	Molin and Brookhuis (2007)	car drivers' beliefs					personal characteristics							problem awareness		
	Garvill et al. (2003)		Traffic pace Exceed	Difficult/easy			Gender	Age						Risk		Moral obligation
	De Mol et al. (2001)	Attitudes to safety		efficiency	Usefulness		socio-demographic backgrounds				satisfaction	willingness to pay		problem awareness		

Table(s)

Table 3. Factor loadings for the pre-defined indicators and (sub)-items

Indicator/variables	Factor 1	Factor 2	Factor 3
Problem Perception			
Accident influence	*Eigenvalues Cumul.:*		*58.22%*
Driving under influence of drugs	-0.08	0.41	0.60
Driving under influence of alcohol	0.00	0.07	0.84
Less driving experience	-0.02	0.87	0.03
Inappropriate speed	0.24	0.04	0.60
Other inexperienced drivers	0.13	0.84	0.10
Bad weather conditions	0.65	0.23	-0.29
Mobile phone use while driving	0.61	0.13	0.18
Bad infrastructure	0.46	0.52	0.23
Risk-seeking behavior	0.64	-0.08	0.48
Fatigue	0.71	0.01	-0.10
No distance keeping	0.70	0.01	0.27
Attitudes about speed and speeding	*Eigenvalues Cumul.:*		*81.98%*
Speeding and danger	0.09	0.93	
Speeding and excitement	0.92	0.02	
Speeding and fun	0.86	0.28	
Speeding and freedom	0.82	0.18	
Speeding and safety	0.23	0.90	
When is speeding not safe	*Eigenvalues Cumul.:*		*80.84%*
Speeding as criminal act in residential zone	0.44	0.82	0.13
Speeding as criminal act in school area	0.56	0.70	0.18
Speeding as criminal act in urban area	0.77	0.44	0.21
Speeding as criminal act outside urban area	0.79	0.35	0.28
Speeding as criminal act on highways	0.67	0.26	0.20
Speeding as irresponsible act in residential zo	0.32	0.86	0.10
Speeding as irresponsible act in school area	0.49	0.72	0.17
Speeding as irresponsible act in urban area	0.78	0.28	0.33
Speeding as irresponsible act outside urban ar	0.78	0.18	0.38
Speeding as irresponsible act on highways	0.75	0.15	0.36
Speeding as 'a mistake' in residential zones	-0.09	0.79	0.52
Speeding as 'a mistake' in school area	0.15	0.51	0.74
Speeding as 'a mistake' in urban area	0.43	0.21	0.79
Speeding as 'a mistake' outside urban area	0.42	0.11	0.81
Speeding as 'a mistake' on highways	0.38	0.11	0.82
Speed limits	*Eigenvalues Cumul.:*		*74.28%*
The best limit in residential zones	0.69		
The best limit in school area	0.81		
The best limit in urban area	0.79		
The best limit' outside urban area	0.80		
The best limit on highways	0.74		
Personal and social aims	*Eigenvalues Cumul.:*		*58.80%*
speeding in normal conditions	0.83		
Speeding when wet surface	0.62		
Speeding during the night	0.67		
Speeding while overtaking	0.71		
Speeding when in a hurry	0.76		
Speeding when the road is familiar	0.87		
Speeding when there is nobody else on the roa	0.80		
Speeding when very little change 'to get caugl	0.80		
Speeding when you will not bring others in da	0.81		
Social norms	*Eigenvalues Cumul.:*		*68.95%*
Speeding to impress others	0.814		
Speeding to compete with other drivers	0.748		
Speeding if other drivers push me to drive fas	0.734		
Speeding when peers of same age as passenge	0.806		
Speeding when passengers	0.742		
Speeding to go with the flow	0.685		
Effectiveness/Efficiency	*Eigenvalues Cumul.:*		*61.46%*
Opinions about measures to counter speeding			
Campaigns to counter speeding	0.42	-0.48	
Speed camera's to counter speeding	0.85	0.03	
Police controls to counter speeding	0.84	0.00	
Speed humps to counter speeding	0.64	0.01	
In-vehicle technology to counter speeding	0.20	0.89	
Opinions about WHICH ISA-effectiveness	*Eigenvalues Cumul.:*		*67.88%*
To cope with the limits in residential area	0.88		
To cope with the limits in urban area	0.88		
To cope with the limits outside urban area	0.87		
To cope with the limits on highways	0.78		
To reduce fuel consumption	0.78		
To reduce emissions	0.77		
To increase traffic safety	0.81		

Indicator/variables	Factor 1	Factor 2	Factor 3	Factor 4
Usefulness				
Opinions about WHICH ITS useful	*Eigenvalues Cumul.:*			*66.15%*
Black box	-0.08	0.20	0.70	-0.15
Alcohol lock (no starting)	0.63	0.11	0.40	0.09
Alcohol warning	0.58	0.27	0.23	0.14
Seat belt reminder: no starting every passen	0.89	0.12	0.06	0.05
Seat belt reminder: no starting driver	0.90	0.20	-0.03	0.02
Collision warning	0.20	0.82	-0.03	0.15
Active cruise control	0.22	0.69	0.36	-0.09
Distance warning	0.16	0.77	0.19	0.10
Supportive ISA	0.22	0.18	0.69	0.32
Informative ISA	0.00	0.25	-0.11	0.81
Closed ISA	0.27	0.04	0.76	0.14
Warning ISA	0.16	-0.09	0.27	0.67
Usefulness Informative ISA	*Eigenvalues Cumul.:*			*89.52%*
Useful-useless	0.94			
Bad-good	0.92			
Effective-superfluous	0.96			
Assisting-worthless	0.96			
Raising Alertness-sleep-inducing	0.95			
Usefulness Warning ISA	*Eigenvalues Cumul.:*			*82.45%*
Useful-useless	0.89			
Bad-good	0.86			
Effective-superfluous	0.93			
Assisting-worthless	0.95			
Raising Alertness-sleep-inducing	0.91			
Usefulness Supportive ISA	*Eigenvalues Cumul.:*			*82.62%*
Useful-useless	0.93			
Bad-good	0.83			
Effective-superfluous	0.93			
Assisting-worthless	0.93			
Raising Alertness-sleep-inducing	0.92			
Satisfaction				
Satisfaction Open ISA	*Eigenvalues Cumul.:*			*90.42%*
Pleasant-unpleasant	0.94			
Nice-annoying	0.96			
Irritating-likeable	0.94			
Undesirable-desirable	0.97			
Satisfaction Warning ISA	*Eigenvalues Cumul.:*			*80.28%*
Pleasant-unpleasant	0.86			
Nice-annoying	0.92			
Irritating-likeable	0.90			
Undesirable-desirable	0.91			
Satisfaction Supportive ISA	*Eigenvalues Cumul.:*			*84.11%*
Pleasant-unpleasant	0.91			
Nice-annoying	0.91			
Irritating-likeable	0.93			
Undesirable-desirable	0.92			
Equity				
Which ISA for who	*Eigenvalues Cumul.:*			*70.62%*
Young drivers	0.87			
Elder drivers	0.86			
All drivers	0.79			
Experienced drivers	0.84			
Vans	0.89			
Trucks	0.85			
Motorcycles	0.84			
Buses	0.86			
Taxi's	0.90			
Bad drivers	0.69			
Which ISA when	*Eigenvalues Cumul.:*			*70.90%*
Informative ISA	0.85			
Warning ISA	0.87			
Supportive ISA	0.81			
Affordability	*Eigenvalues Cumul.:*			*70.11%*
Informative ISA	0.81			
Warning ISA	0.89			
Supportive ISA	0.81			

Table(s)

Table 4. Correlations between different items and indicators based on results of the pilot survey

	Acceptability of ISA system	Accident influence	Attitudes about speed and speeding	When is speeding not safe	Speed limits	Personal and social aims	Social norms	Opinions about measures to counter speeding	Opinions about WHICH ISA-effectiveness	Opinions about WHICH ITS useful	Usefulness Informative ISA	Usefulness Warning ISA	Usefulness Supportive ISA	Satisfaction Open ISA	Satisfaction Warning ISA	Satisfaction Supportive ISA	Which ISA for who	Which ISA when	Affordability
Acceptability of ISA system						-,243**	-,210**		,462**	,406**	-,532**	,203**	,692**	-,544**	,204**	,693**	,422**	-,284**	-,243**
Problem Perception																			
Accident influence			,308**	,200*	-,225**	,311**			,236**										
Attitudes about speed and speedi		,308**			-,465**	-,428**		,345**	,265**									-,219**	
When is speeding not safe		,200*			,350**	,249**	,214**											,211**	,217**
Speed limits		-,225**	-,465**	,350**		,456**		-,265**	-,303**	-,225**									,232**
Personal and sc	-,243**	,311**	-,428**	,249**	,456**		,313**	-,267**	-,250**	-,278**								,309**	,278**
Social norms	-,210**			,214**		,313**				-,228**									
Effectiveness/Efficiency																			
Opinions about measures to coun		,464**	,345**		-,265**	-,267**			,243**	,272**									
Opinions about '	,462**	,236**	,265**		-,303**	-,250**		,243**		,387**	-,262**		,400**	-,275**		,423**	,513**	-,266**	-,238**
Usefulness																			
Opinions about '	,406**				-,225**	-,278**	-,228**	,272**	,387**		-,261**		,439**	-,260**		,429**	,364**	-,255**	-,310**
Usefulness Infor	-,532**								-,262**	-,261**				,961**			-,202*		
Usefulness Warı	,203**														,909**				
Usefulness Supp	,692**								,400**	,439**						,932**	,352**		
Satisfaction																			
Satisfaction Ope	-,544**								-,275**	-,260**	,961**						-,217**		
Satisfaction Wa	,204**											,909**							
Satisfaction Sup	,693**								,423**	,429**			,932**				,436**		
Equity																			
Which ISA for v	,422**								,513**	,364**	-,202*		,352**	-,217**		,436**			
Which ISA whe	-,284**		-,219**	,211**		,309**			-,266**	-,255**						-,180*			,506**
Affordability	-,243**			,217**	,232**	,278**			-,238**	-,310**								,506**	

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).