Predicting the acceptance of advanced rider assistance systems

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A B S T R A C T
The strong prevalence of human error as a crash causation factor in motorcycle accidents calls for countermeasures that help tackling this issue. Advanced rider assistance systems pursue this goal, providing the riders with support and thus contributing to the prevention of crashes. However, the systems can only enhance riding safety if the riders use them. For this reason, acceptance is a decisive aspect to be considered in the development process of such systems. In order to be able to improve behavioural acceptance, the factors that influence the intention to use the system need to be identified. This paper examines the particularities of motorcycle riding and the characteristics of this user group that should be considered when predicting the acceptance of advanced rider assistance systems. Founded on theories predicting behavioural intention, the acceptance of technologies and the acceptance of driver support systems, a model on the acceptance of advanced rider assistance systems is proposed, including the perceived safety when riding without support, the interface design and the social norm as determinants of the usage intention. Since actual usage cannot be measured in the development stage of the systems, the willingness to have the system installed on the own motorcycle and the willingness to pay for the system are analyzed, constituting relevant conditions that allow for actual usage at a later stage. Its validation with the results from user tests on four advanced rider assistance systems allows confirming the social norm and the interface design as powerful predictors of the acceptance of ARAS, while the extent of perceived safety when riding without support did not have any predictive value in the present study.

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1. Introduction
Contrary to the general decrease in traffic accidents that has been achieved during the last decade in Europe, motorcycle fatality rates have still been rising in many countries (IRTAD, 2010). The fatality risk of this road user group cannot be specified exactly, because accurate exposure data is lacking (ETSC, 2008), yet there is a clear overrepresentation of riders among crash victims on a world-wide scale (WHO, 2004). Riders are more vulnerable to injury and crash-related disability than drivers of other vehicles (Elliott et al., 2007; Mayou and Bryant, 2003) since they are not protected by the bodywork of their vehicle, and avoiding any collision must therefore have highest priority for them (Pai, 2011; Cheng and Ng, 2010).

The most prominent crash scenarios for motorcycle riders are single vehicle accidents on bends, with the rider losing control due to inappropriate speed, and front-side crashes at intersections, most commonly resulting from a right-of-way violation by another vehicle (e.g. Hurt et al., 1981; MAIDS, 2004; TRACE, 2008). Less frequently, motorcyclists are involved in rear-end and side–side crashes (TRACE, 2008). The latter may be related to overtaking and other behaviours riders have increased opportunities to perform due to the manoeuvrability of their vehicle (Clarke et al., 2004).

Analyses of the time and location of fatal motorcycle crashes registered in the German official accident statistics (Assing, 2002) suggest that rather than being a functional means of transport, riding is often a leisure activity. Correspondingly, passion for motorcycles, performance and the experience of sensations have been identified as predominant riding motives (Christmas et al., 2009; Jamson and Chorlton, 2009). Provided that intrinsic motivations such as the sensations produced when riding play a more important role than extrinsic motivations related to mobility (Broughton, 2008), the psychological flow theory (Csikszentmihalyi, 1997) may apply to motorcycle riding. People experience flow when their abilities match the difficulties of the activity they are carrying out, when they feel in control and reach a high level of concentration on the task. The tendency to match risk level and skills or to maintain an optimal task difficulty has been discussed regarding car driving (Fuller, 2005; Wilde, 1982). In the context of motorcycle riding, Broughton and Stradling (2005) found that almost 50% of the riders experience risk as control and consider it desirable up to a certain threshold (risk-acceptors), whereas only a relatively small percentage of riders were active risk-seekers.
Considering the phenomenon of risk compensation, Chesham et al. (1993) concluded that riding safety could only be improved by modifying this level of accepted risk. Moreover, the riders' subjective assessments of risk often do not correspond with expert ratings of risk (Bellaby and Lawrenson, 2001) and risky riding behaviours might be linked to the riders' underestimation of their likelihood of being involved in an accident, as it has been observed for car drivers (Manering and Grodsky, 1995; Deery, 1999). Hence, it is crucial for riding safety that the riders are aware of their crash risk in any riding situation, and that biased risk perception is avoided.

Motorcycle riding is a challenging task that requires a high level of coordination and balance skill (Manering and Grodsky, 1995), as well as constant hazard monitoring (Haworth et al., 2005). The capability to identify situations that imply a potential danger on the road (Crick and McKenna, 1992) has proven to be associated with accident involvement (Cheng et al., 2011). Appropriately judging the road situation and choosing the corresponding reactions and anticipatory behaviour are of utmost importance when it comes to avoiding crashes (DEKRA, 2010; Di Stasi et al., 2009). Human error has been identified as the primary crash contributing factor in 87.5% of all accidents involving a motorcycle (MAIDS, 2004): In 37.1% of these cases, the error had been committed by the rider, while other road users had been at fault in 50.4%. Other drivers often overlook motorcycles due to their low conspicuity and they frequently misjudge the rider's approach speed and arrival time (e.g. Shahar et al., 2012). Although the riders may not be responsible for the resulting right-of-way crashes, they can contribute to the occurrence of the crash situation by their riding style and by failing to adjust their behaviour so as to avoid the collision (2 BE SAFE, 2010). Errors underlying the crashes analyzed in MAIDS (2004) include inattention, traffic scan failures, perception failures and decision failures. Such human errors become manifest as inappropriate speed choice, right of way violations, low safety headways and errors when overtaking (DEKRA, 2010). Data on collision avoidance manoeuvres indicates that the riders did not have time to even initiate an evasive action in one third of the collisions with an obstacle (MAIDS, 2004). Overconfidence in anticipatory abilities on how a situation will evolve and speed choice play an important role here (2 BE SAFE, 2010). While exceeding the speed limit turned out to be a crash causation factor in few cases only, riding too fast for the prevailing conditions has been found of considerable relevance for crash risk (Clarke et al., 2004; Lin et al., 2003).

With the aim of specifically tackling these safety flaws by warning the riders in especially risky scenarios and thus helping to prevent human error related crashes, the following four advanced rider assistance systems (ARAS) have been developed and tested with users within the European project SAFERIDER (SAFERIDER, 2010). The Curve Warning system alerts riders whenever they are approaching a curve at an inappropriate speed and the Intersection Support system warns riders if they need to reduce speed in order to safely manage an intersection situation. The Frontal Collision Warning system alerts of a longitudinal distance that is getting critical and, finally, the Lane Change Support system provides riders with a warning whenever they are about to change the lane cutting into another vehicles trajectory. The systems calculate the safe reference manoeuvre corresponding to their support function in real time and compare it with the actual riding parameters. Whenever the difference between the optimal riding manoeuvre and the one carried out by the rider reaches a critical threshold, the rider is warned. This way, the riders only receive a warning if they do not adapt their behaviour appropriately to the road situation, and redundant messages that could annoy or disturb the riders are avoided. The warning is presented to the rider as a haptic feedback. Depending on the interface installed, it is applied to the throttle, the handlebar, the glove or the helmet. As soon as the rider’s behaviour sufficiently approximates the safe reference manoeuvre, the warning ceases.

As a basic condition for the systems to be able to reach their safety potential and reduce the crash risk of motorcyclists, they need to be accepted by the riders. This implies the riders’ willingness to acquire and install the systems on their motorcycles and to use them (Müller et al., 2008; Adell, 2010). In the automotive domain user acceptance has proven of utmost importance for the successful implementation of driver support systems and, as a consequence, an early consideration of the acceptance concept within the product development process has been claimed (Arndt and Engeln, 2008; Kassner and Vollrath, 2006). This paper presents a model that aims at predicting the riders’ acceptance of ARAS and its validation with user tests on the four systems described above.

2. Theoretical framework

In the evaluation of ARAS behavioural acceptance is the most pertinent of all prevailing acceptance concepts (Schade, 2005; Adell, 2009), since the systems can only be beneficial for riding safety if they are actually used by the rider. As stated by Van der Laan et al. (1997) “it is unproductive to invest effort in designing . . . if the system is never switched on or even disabled” (p. 1). As long as a system is not yet introduced to the market and cannot be acquired and used by riders, the actual usage behaviour cannot be measured. In the development stage of a system the usage intention has therefore to be focussed. Ajzen (1991) postulated the behavioural intention as being a direct determinant of actual behaviour in the Theory of Planned Behaviour, and numerous studies with different backgrounds provide evidence for this relationship. For instance, Montada and Kals (2000) identified the willingness to show a specific behaviour as a valid predictor of the execution of that behaviour in the context of proenvironmental commitment.

In the context of advanced driver assistance systems (ADAS), acceptance is also approached as behaviour (Arndt, 2004, cited in Arndt and Engeln, 2008). In this line, Adell (2010) postulated that acceptance is “the degree to which an individual intends to use a system in his/her driving” (p. 477). In this perspective, the expression of a usage intention as the decisive element eclipses the evaluation of a system in terms of likes or dislikes.

In order to be able to enhance this acceptance, it is necessary to know which factors influence it and to include their measurement into the assessment of the system. Even though the acceptance of technology has been extensively studied, there is neither a unified theoretical approach nor a standardized measurement procedure (Adell, 2009; Schade, 2005). When predicting the acceptance of ARAS in particular, the peculiarities of motorcycle riding and the needs of this user group have to be considered. Based on concepts that have proven relevant for motorcycle riding, the acceptance model presented in this paper aims at predicting the riders’ usage intention of the ARAS by three factors: the perceived safety when riding without support, the interface design and the social norm. Their theoretical foundation is outlined in the following paragraphs.

The intention to use ARAS can be expected to depend on the subjective need for assistance, as motives referring to the nature of riding as a performance may interfere with the perceived usefulness of the system in terms of self-efficacy (Bandura, 1982). Several theories on the acceptance of technology include the aspect of perceived usefulness, i.e. the perceived benefits when using the system (e.g., Davis, 1989; Van der Laan et al., 1997; Venkatesh and Davis, 2000). In order to recognize the relevance of road safety solutions, users must be aware of the problem the countermeasures are intended to tackle (Schlag, 1997; Steg and Vleg, 1997). Accordingly,
acceptance models of ADAS consider that the users must have the necessary problem awareness so as to perceive benefits from using the system and thus to build a usage intention (Arndt and Engeln, 2008; Müller et al., 2008). Specifically, Müller et al. (2008) establish the fear of being involved in an accident as a relevant predictor of the intention to use an ADAS. In the context of the present study, the need for assistance is assumed to result from the safety feeling when riding without the system. The assistance systems have been developed based on common accident scenarios, where the system could enhance the riding safety. Yet, only if the riders are aware of the risk they are taking in the specific situations for which the support has been designed for, will they accept the function as a subjectively meaningful safety measure. Thus, the degree of perceived safety when riding without the system has been selected as the first predictor in the model.

A further concept related to the users’ attitude towards systems is their pleasantness or hedonic quality (e.g., Hassenzahl et al., 2000; Van der Laan et al., 1997). This aspect mainly refers to the interaction with the system and may not apply to ARAS, which monitor specific critical aspects of the ride and emit warnings in case of danger. Just as ADAS, they do not require input from the user and only interact with the driver when there is a need to provide a warning (Adell, 2010). Nevertheless, the interface design is expected to play a crucial role regarding its possible interference with the satisfaction of emotional needs like the enjoyment of the ride. The expressive nature of motorcycle allows the riders to live emotions like thrill and feelings of freedom (Broughton and Stradling, 2005; Broughton, 2007; Haworth, 2012), and behavioural decisions related to motorcycle riding might therefore be influenced by emotional factors instead of more rational criteria. Indeed, Elliott (2010) found that affective attitudes play a significant role when predicting motorcyclists’ intention to speed. In the present context, a crucial factor for the behavioural acceptance of ARAS may be the disturbance of riding sensations by the warnings, and the extent to which the warnings give the impression to be taking away the control or autonomy from the rider. The interface design, operationalized by the users’ judgement on the warning presentation, therefore constitutes the second predictor in the model.

Riding has strong social components, given that it is often carried out as a group activity (Broughton, 2007; Krige, 1995). Tunnicliff et al. (in press) found that riders are subject to considerable influence by the members of their group and that specific group identities exist, including norms regarding beliefs, expectations and behaviours. Thus, decisions and choices riders take concerning safety related behaviour might depend on their fellow riders’ opinion, i.e. the social norm might be relevant in predicting the riders’ acceptance of ARAS. The social norm has been established as a predictor of behavioural intention in the Theory of Planned Behaviour (Ajzen, 1991). It refers to the beliefs on the opinion of important others and to the perceived social pressure to show or not to show a certain behaviour. However, the traditional subjective norm concept has been a rather unstable variable (Armitage and Conner, 2001; Terry and Hogg, 1996; Terry et al., 1999; Venkatesh and Davis, 2000) and it was therefore adjusted to capture social influence more adequately by referring to a more specific group. The reference group of ‘other drivers’ or ‘fellow riders’ has proven relevant regarding road user behaviour (Tunnicliff et al., in press) and, in particular, motorcyclists’ intention to speed (Elliott, 2010). In the context of ADAS the importance of the social influence has been recognized as a powerful predictor of the usage intention (Adell, 2010; Arndt and Engeln, 2008; Müller et al., 2008). Taking into account the popularity of riding in groups and the strong relationships that are usually shaped among riders (Tunnicliff et al., 2011), the presence of the relevant people might even enhance the influence of the subjective norm (Parker et al., 1992). As a measurement of the social norm, the expected opinion of fellow riders about the system is hence established as the third predictor in the model.

At a stage where the actual usage of a system cannot yet be determined, it is nonetheless possible to quantify relevant conditions that may withhold a user from acquiring a system, and thus from being able to actually use it. The willingness to have the system installed on the own motorcycle and the willingness to spend money for acquiring the system are such factors (Arndt and Engeln, 2008; Müller et al., 2008). For this reason, the relationship between these variables and the usage intention has been analyzed in the present study.

The resulting model on the acceptance of ARAS is presented in Fig. 1. The aim of the study was to validate this model with data collected in several user tests. The relevance of the three predictors of the usage intention (i.e. behavioural acceptance) had to be determined and the extent of the relation between the usage intention, the willingness to have the system installed on the own motorcycle and the willingness to pay for the system had to be examined. All relationships are hypothesized positive except ‘perceived safety’, which refers to the safety feeling when riding without support and is supposed to have a negative influence on the usage intention.

3. Method

3.1. Participants

For the validation of the proposed model, data from the user tests that have evaluated the prototypes of the four ARAS described above was analyzed. The participation in the experiments was voluntary and unremunerated. A total of N = 171 participants provided valid and complete data sets. Of those, n = 151 were male and n = 20 were female riders, covering a range of 21–55 years of age (M = 30, SD = 8.24). Participants claimed an average mileage of 9344 km with the motorcycle during the last 12 months. Most of them were regular riders, saying they use the motorcycle several days a week or every day (n = 140), while the remaining participants (n = 31) stated riding only on weekends or less frequently than once a week. The principal riding motive indicated by the participants was ‘fun’ in n = 108 cases and ‘commuting or mobility needs’ in n = 59 cases (n = 4 cases were missing).

3.2. Materials

A common questionnaire had been developed specifically for all the ARAS user tests, assessing different aspects of the ride and the system used. Only those variables that were identified as relevant for the model were selected for the validation of the acceptance model. The items employed are listed in Table 1, where their wording and answering options are detailed. Each part of the acceptance model was represented by one questionnaire item.

Questionnaire data was available from experiments in two simulators (Italy and France) and a closed test track (Italy). The latter permitted testing the system on a real motorcycle in specifically created situations and under controlled traffic conditions. Both dynamic simulators were equipped with an instrumented motorcycle mock-up as well as systems transmitting motion, visual and acoustic cues to the rider. The virtual environment allowed the participants to ride through predefined situations and to interact with other road users.

In the Italian riding simulator in Padova, the Curve Warning system and the Intersection Support system were tested with two different rider interfaces each. In the French riding simulator in Paris, user tests were carried out on the Frontal Collision Warning system and the Lane Change Support system, again combining
them with two alternative rider interfaces. On the test track at Teresë (Italy), a further version of the Curve Warning system and the Frontal Collision Warning system were evaluated.

For each ARAS a dedicated test route had been created, focusing on situations relevant to the support function of the specific system. Although all riders went through the same test route, the critical situations they experienced depended on their individual riding behaviour. Since all ARAS emitted a warning only in case of a detected mismatch between the actual rider behaviour and the safe manoeuvre calculated by the system, the number of warning situations varied among the participants. Yet, the test routes were designed in ways that maximized the likelihood of warnings, so as to assure that the participants gather sufficient experience to conceive an opinion about the system.

### 3.3. Procedure

After a familiarization and instruction phase, the participants rode the system-specific test route once without the ARAS (baseline) and once with the respective system activated. Each of these two rides test ride took approximately 30 min and their order was counterbalanced. After each ride the participants completed the questionnaire in electronic format.

#### 3.4. Data analysis

Only the variables selected for the validation of the model were included in the data analysis (cf. Table 1). The items stemmed from those questionnaires administered after the ride with the ARAS, except for the perceived safety when riding without support, which was measured after the baseline ride. A binary logistic regression was calculated in order to determine the degree to which the three predictors discriminate between usage intenders and non-intenders (dependent variable).

Given that the treatment of the employed answering scale of the predictors as a continuous measure might be arguable, a second regression was calculated so as to test the robustness of the effects. For this model, the five-point scales were categorized into negative (1–2), neutral (3) and positive (4–5) responses. In the regression with the categorical predictors backward difference coding (comparing each level to the prior level) was used, accounting for the ordinal character of the data.

Additionally, possible influences of demographic parameters were explored by means of a stepwise logistic regression (backward), with the three main predictors and the following variables: age (continuous), average mileage during the last 12 months (continuous), frequent rider (yes/no) and riding motive (fun/mobility). The relationship between the significant predictors and the correlations between the usage intention, the willingness to have the system installed on the own motorcycle and the willingness to spend money for it were analyzed by means of pairwise Spearman’s Rho coefficients.

### 4. Results

\( N = 25 \) participants were identified as non-intenders, indicating that they would not activate the system at all if they had it on their motorcycle and \( n = 146 \) riders were classified as intenders, who said they would activate the respective ARAS at least in certain situations. Descriptive statistics of the variables used in the model are shown in Table 2, comparing the answers of intenders and non-intenders.

Table 3 shows the results of the logistic regression with the untransformed predictors. The perceived social norm has the most pronounced predictive power with a highly significant positive effect on the usage intention. The stronger the riders believe that their fellow riders would appreciate the system the more likely they are to intend to use the system themselves. The interface design is also a highly significant predictor of the usage intention. A better assessment of the warning presentation has a positive influence on the riders’ intention to use the system. Against expectations, no
influence of the safety feeling during the baseline ride on the usage intention of the system could be detected.

The suggested model is a good fit and has an explanatory power of 52% (Table 3). The correlation of \( r = .44 \) between the predictors ‘social norm’ and ‘warning presentation’ is significant but acceptable for the model, since it still allows the two variables to contribute an independent share to the prediction.

The distribution that results from the categorization of the scales is shown in Table 4, contrasting the answers of intenders and non-intenders. The regression with the categorical predictors confirms the results obtained in the first model: The interface design and the subjective norm are significant predictors of the usage intention (Table 5). The odds of being a usage intender are significantly increased for neutral compared to negative responses regarding the interface design and the social norm. However, the effect of positive responses compared to neutral responses is only marginal for the interface design and non-significant for the social norm. These results suggest that, in order to build a usage intention, it is more important that the riders do not disapprove the interface design than that their judgement is clearly positive. Regarding the social norm, riders who believe their fellow riders have a negative attitude towards the ARAS are less likely to be usage intenders than those who estimate their fellow riders have a neutral or positive opinion about the system. The distribution of the answers regarding the safety feeling when riding without the ARAS (cf. Table 4) hint at a ceiling effect which might explain why this variable has no predictive value in the presented models. The goodness of fit and coefficient of determination of the second model (cf. Table 5) are comparable to the figures of the first regression.

The additional regression analysis showed that none of the included demographic variables significantly contributes to predicting the usage intention.

As shown in Table 6, the usage intention was significantly correlated with both the willingness to have the system and the willingness to pay for it. Likewise, these two variables correlated significantly with each other. It seems that riders who express their intention to use the system if they had it installed on their bike are also keen on acquiring the system. They are more willing to have the system on their own motorcycle and are more prepared to spend money for it than those riders who do not express a usage intention.

5. Discussion

The proposed model on the acceptance of ARAS could be confirmed in parts by the available data. The social norm and the appraisal of the interface design have proven powerful in the prediction of the usage intention of an ARAS, whereas the safety feeling when riding without support was non-significant as a predictor in the model. Nevertheless, both the predictive power of the presented model and the extent of the correlations found among the variables leave room for other determinants beyond this model to explain the variance of the usage intention.

While the classical concept of the social norm as part of Ajzen’s (1991) Theory of Planned Behaviour did not show to be robust in various cases (rider behaviour: Elliott, 2010; system usage: Venkatesh and Davis, 2000), the specific social influence of peers confirmed for the acceptance of ADAS (Arndt and Engeln, 2008) has proven to have a strong influence on the acceptance of ARAS in the present study. This finding reveals the impact that preconceptions regarding the support systems, which might be present in rider circles, may have on the acceptance of the ARAS by an individual. Accordingly, it lends importance to promoting a favourable

### Table 2
Descriptive parameters of the responses of intenders and non-intenders.

<table>
<thead>
<tr>
<th>Item</th>
<th>Intenders (N=146)</th>
<th>Non-intenders (N=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1</td>
<td>Md</td>
</tr>
<tr>
<td>How safe did you feel when riding without the system?</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Did you like how the warning as presented?</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Do you think your fellow riders would appreciate the system?</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 3
Results of the logistic regression model with the three predictors of the usage intention.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>p</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived safety (ride without ARAS)</td>
<td>.091</td>
<td>.297</td>
<td>.233</td>
<td>1</td>
<td>.630</td>
<td>1.154</td>
</tr>
<tr>
<td>Interface design</td>
<td>.821</td>
<td>.350</td>
<td>16.826</td>
<td>1</td>
<td>.000</td>
<td>4.202</td>
</tr>
<tr>
<td>Social norm</td>
<td>1.436</td>
<td>1.318</td>
<td>11.215</td>
<td>1</td>
<td>.001</td>
<td>.012</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.413</td>
<td>1.318</td>
<td>11.215</td>
<td>1</td>
<td>.001</td>
<td>.012</td>
</tr>
</tbody>
</table>

N = 171; Hosmer Lemeshow goodness of fit: Chi²(8) = 5202; p = .736; Nagelkerke R² = .52.

### Table 4
Number of observations in the categories of the predictors for intenders and non-intenders.

<table>
<thead>
<tr>
<th></th>
<th>Intenders</th>
<th>Non-intenders</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived safety (N=171)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>12</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Neutral</td>
<td>41</td>
<td>13</td>
<td>54</td>
</tr>
<tr>
<td>Positive</td>
<td>93</td>
<td>9</td>
<td>102</td>
</tr>
<tr>
<td>Interface design (N=171)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>31</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>Neutral</td>
<td>43</td>
<td>3</td>
<td>46</td>
</tr>
<tr>
<td>Positive</td>
<td>72</td>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>Social norm (N=171)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>30</td>
<td>22</td>
<td>52</td>
</tr>
<tr>
<td>Neutral</td>
<td>53</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>Positive</td>
<td>63</td>
<td>2</td>
<td>65</td>
</tr>
</tbody>
</table>
Table 5
Results of the logistic regression model with the categorized predictors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$B$</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>$p$</th>
<th>Exp($B$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived safety (ride without ARAS)</td>
<td>1.972</td>
<td>2</td>
<td>.373</td>
<td>.454</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral vs. negative</td>
<td>- .789</td>
<td>.911</td>
<td>750</td>
<td>1</td>
<td>.386</td>
<td>1.052</td>
</tr>
<tr>
<td>Positive vs. neutral</td>
<td>.414</td>
<td>.629</td>
<td>.433</td>
<td>1</td>
<td>.511</td>
<td>1.512</td>
</tr>
<tr>
<td>Interface design</td>
<td>10.954</td>
<td>2</td>
<td>.004</td>
<td>5.723</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral vs. negative</td>
<td>1.744</td>
<td>.752</td>
<td>5.378</td>
<td>1</td>
<td>.020</td>
<td>1.040</td>
</tr>
<tr>
<td>Positive vs. neutral</td>
<td>1.264</td>
<td>.750</td>
<td>2.844</td>
<td>1</td>
<td>.092</td>
<td>1.057</td>
</tr>
<tr>
<td>Social norm</td>
<td>14.947</td>
<td>2</td>
<td>.001</td>
<td>3.540</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral vs. negative</td>
<td>3.193</td>
<td>1.075</td>
<td>8.827</td>
<td>1</td>
<td>.003</td>
<td>2.462</td>
</tr>
<tr>
<td>Positive vs. neutral</td>
<td>.740</td>
<td>.934</td>
<td>.627</td>
<td>1</td>
<td>.428</td>
<td>1.296</td>
</tr>
<tr>
<td>Constant</td>
<td>2.789</td>
<td>.517</td>
<td>29.068</td>
<td>1</td>
<td>.000</td>
<td>16.266</td>
</tr>
</tbody>
</table>

$N=171$; Hosmer-Lemeshow goodness of fit: $Chi^2(7)= 4176; p=.596$; Nagelkerke $R^2=.50$.

attitude towards such solutions amongst motorcycle riders, with the particular aim of avoiding a distinctly negative social norm.

As a limitation to this result, it should be considered that the discovered relationship is based on subjective data and a person’s statements of opinion might influence each other. In this manner, it cannot be ruled out with certainty that the riders’ own acceptance of the ARAS influences them to believe that fellow riders would appreciate the system.

The high relevance of the riders’ appraisal of the warning presentation for the prediction of the usage intention corresponds with the findings of an assessment of the Curve Warning system reported by Huth et al. (2012), which showed a strong dependence of the system evaluation on the rider interface used. Again the decisive issue seems to be the avoidance of a negative appreciation of the interface by the rider, whereas a benefit of explicitly positive assessments only appears as a tendency. In this context, future studies should also investigate the influence of the customizability of the warnings and their thresholds as a potentially powerful predictor of the riders’ acceptance. The results of the evaluation of the Curve Warning system (Huth et al., 2012) and the Intersection Support system (Huth et al., in press), as well as the findings from the automotive domain (e.g. Jiménez et al., in press) point towards a possible relationship between the adaptability of system characteristics to different user needs or situational conditions and the behavioural acceptance by the riders. The diversity of motorcycle types and the large inter-individual differences that exist among rider personalities and skill levels lend particular importance to this issue, which should not be neglected in the further development process of ARAS and the research on their acceptance.

The irrelevance of the perceived safety when riding without support as a predictor of the behavioural acceptance is contradictory to the recognized positive effects of a high problem awareness on the acceptance of related solutions (Vlassenroot et al., 2010). More specifically, it rebuts the assumption that the awareness of the crash risk, resulting in a perceived usefulness attributed to the system, would increase the intention to make use of the support solution. However, this finding coincides with the results obtained for driver support systems. Against their expectations, Arndt and Engeln (2008) have not been able to consolidate the relationship between the problem awareness and the intention to use ADAS either. Future studies need to further analyse whether the measurement of the problem awareness needs to be adapted to a more pertinent aspect (cf. potential ceiling effect in this study), or this factor can be confirmed as irrelevant in the prediction of the acceptance of ARAS.

The results on the willingness to have the system installed on the own motorcycle and the willingness to pay for the system suggest that a usage intention built by the riders will come along with the necessary preparedness to create the conditions that allow for actual system usage. Still, it has to be considered that the correlation of the willingness to pay for the system and the usage intention was relatively low in the present study (though significant). The data analyzed by Arndt and Engeln (2008) indicated that the willingness to pay for ADAS and the usage intention did not correlate significantly. Yet, it should be noted that not all the participants had got the chance to test the systems in their study and the measures partly have to be interpreted within the concept of acceptability rather than acceptance, i.e. as an attitude construct formed without experiences with the system (Schade and Schlag, 2003). At the example of the Curve Warning system, Huth et al. (2012) referred to the convenience to develop economic solutions of the support systems, in order to make sure that the financial aspect does not hinder a wide distribution of the ARAS among users.

Due to the heterogeneity of system functions used in the present study, no statements can be issued on predicting the acceptance of a specific system. Yet, the aim of this research was to find person-related factors with an influence on the behavioural acceptance which are independent from specific attributes of the ARAS and which can be generalized to any comparable system (cf. Arndt and Engeln, 2008).

The present work undertakes the important step from the acceptability of possible systems to the acceptance of systems that have been practically experienced by test riders. Nevertheless, only behavioural intention could be measured, not actual behaviour. Although there is a direct link between an intention and the corresponding behaviour, it cannot be assumed with all certainty that the factors predicting the usage intention will be the ones which best predict the actual usage. The relatively low correlation of the willingness to pay for the system with the behavioural intention indicates that there might be factors which can impede the usage of the systems, just as there may be others that facilitate their use. Further studies are needed to investigate this issue. Once the systems are on the market, the approach of acceptance in terms of actual behaviour should be adopted by future research, studying usage behaviour extensively in this framework.

As an added limitation, the present study only uses one item for each predictor of the model. For better reliability, future studies should establish a set of questions referring to the three concepts that constitute the predictors. Finally, the results presented in this

Table 6
Correlations (Spearman’s Rho): usage intention, willingness to have, willingness to pay.

<table>
<thead>
<tr>
<th>Usage intention</th>
<th>Willingness to have</th>
<th>Willingness to pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>.49</td>
<td>.29</td>
</tr>
<tr>
<td>$p$</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>$N$</td>
<td>171</td>
<td>171</td>
</tr>
</tbody>
</table>

| Willingness to pay | Correlation | .39 | .000 | 171 |

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paper are restricted to the validation with a given subject sample. Whenever studies are carried out with volunteers self-selection processes cannot be ruled out, such as the attraction of individuals who are more safety-conscious and less risk-seeking.

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