The acceptance of Assistive Systems by motorcycle riders

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Abstract:

The development of assistive systems for improving the safety of powered two-wheelers (PTWs) is of utmost importance. By now, the use of safety-enhancing assistive systems for passenger and commercial vehicles, including Advanced Driver Assistance Systems (ADAS) and In-Vehicle Information Systems (IVIS) is quite commonplace in many countries. By comparison, only a limited amount of the PTW equivalents, namely Advanced Rider Assistance Systems (ARAS) and On-Bike Information Systems (OBIS) have been developed so far. Estimates suggest that population-wide deployment of ARAS could reduce crashes by up to 40% (Rakotonirainy et al., 2006 [12]). The objective of the project "2-Wheeler Behaviour and Safety "2BESAFE)" was to identify the factors that affect the acceptance of ARAS and OBIS of PTW riders and single out obstacles that maybe discourage drivers from using them (Lenné et al., 2011 [10]). For this purpose a literature review, focus group interviews and an online survey have been conducted. The obtained answers show that the acceptance of these systems derives from their function and it proved to be higher if the systems were more useful in emergencies. There is also a perceivable move from a mere development of assistive systems only to the dangers that motorcyclists face from other vehicles and also to the rider training.

1. Acceptability of ARAS and OBIS

Only if the users (a specific target group) appreciate these technologies as sensible and beneficial, can safety systems successfully reduce the occurrence and severity of road crashes. The barriers that hinder both, the acceptance and proper use of ARAS and OBIS must be well identified.

Subsequently, the focus of the study lay on the investigation to what extend individual factors like riding style, safety attitudes and risk behaviours support the acceptance of such systems. Research into literature, qualitative focus group interviews with motorcycle riders as well as a quantitative large-scale online survey were employed for this purpose.

An overview of the procedure reads like follow: State-of-the-Art research; description of the focus group interviews; quantitative online survey; statistical methods employed in the analysis of the survey data.

1.1. Current State-of-the-Art of ARAS and OBIS, crash types and models on acceptance and acceptability

Only a few assistive technologies have been developed for motorcycle riders. In 2006 less than ten ITS products for PTW were available on the market (Bayly et al., 2006 [2]). In a provisional agreement reached between the European Parliament and Council of Ministers in 09/2012 it was decided to make the Anti-lock braking system (ABS) mandatory on motorcycles with more than 125cc by 2016 (EC-Press release, 12/2012 [7]).

A closer inspection of the different types of PTW crashes may help to identify the potential gain of assistive technologies. PTW crashes appear to vary internationally, depending on a number of factors such as the prevalence of PTW riders, reason for riding the PTW, amount of riding exposure, type of PTW ridden etc. In addition to this, PTW riders face a number of risk factors that do not affect car drivers:

1. Vulnerability: PTWs have low stability at a relatively high speed and a much lower level of occupant protection than a car provides (ETSC, 2008 [6]). The relations between riding speed and the injury risk are well known, but less is known about the link between speed and frequency of crashes (Quellet et al., 2006 [10]).

Increase of injury severity during the crash: PTW riders often sustain multiple injuries with head injuries the most frequent in fatal crashes (Kraus, 1989 [9]).

2. Conspicuity: PTWs are less visible to other road users compared to cars or trucks due to smaller vehicle size and often dark colours (concerning both motorcycle and motorcycle rider's clothes). Also sensory and cognitive conspicuity of PTW are lower than those of cars and trucks. PTW characteristics are (manoeuvrability, acceleration, braking etc.) different from those of cars which often do not comply with car driver's expectations, in other words, car drivers expect other cars on the road (Brenac et al., 2006 [3])

Numerous PTW crashes can be derived from rider characteristics. The MAIDS study found that the leading cause of PTW crashes was human error (ACEM, 2009 [1]). For example, the most frequent human error (50%) was a failure to detect the PTW within the traffic environment, caused by the lack of driver's attention, temporary view obstructions or the low conspicuity of the PTW. Novice riders can be seen as the group of riders with the greatest injury risk (Gregersen et al., 2003 [8]).

Following classifications of assistive systems were made in this study:

1. Differentiation in active and passive systems

- Active systems act prior to crash occurrence, some of them reduce the probability of the crash.
- Passive systems reduce the effects of a crash once it has occurred or is occurring.

2. Differentiation according to the level of intervention of the system with the rider's behaviour

- Informative systems which provide information on speed, navigation, dangers etc. to the PTW rider
- Warning systems which transmit alerts to the rider (tactile, sensoric etc.)
- Intervening systems which intervene directly with the driving process

Only few studies address acceptability of assistive systems for PTWs. Cairney and Ritzinger (2008 [4]) investigated acceptability of ISA (Intelligent speed adaptation), ACN (Automatic Crash Notification) and Anti-lock braking system (ABS) in Australia. Riders expressed mixed feelings towards all three systems. Certain barriers in the acceptance of specific systems were noted, most of them related to the perceived benefits or effectiveness. This includes the "skills rather than technology" argument: some riders believe that such systems may inhibit the development of riding skills and that a comparable (or superior) degree of safety could be achieved by improvements in the riders' training. This is one major barrier because it puts a limit to perceived usability and satisfaction and has serious implications relating to system reliability: riders who were of this opinion will not endorse a system unless it is 100% reliable because of their concerns that if the system does fail then riders will not know how to respond appropriately. Cost was also a major barrier as most riders believe that retroactive fitting of these systems onto the motorcycle costs too much.

Contrary to infrastructure-based ITS, riders will have the choice to decide which type of ARAS or OBIS they will fit on their motorcycle, provided that they are not mandatory. Therefore only technologies which are accepted by the users will successfully reduce the occurrence and severity of road crashes and have a positive effect on driver behaviour and crash risk. Cost arguments play a decisive role when it comes to designing and investing in new technologies. If newly developed systems are not purchased by the consumer or are purchased but never used, their economic feasibility is highly questionable (Van de Laan et al., 1997 [15]).

The model of Schade and Schlag (2003 [13]) distinguishes between acceptability and acceptance. Acceptability is defined as a prospective judgement regarding a system that has not yet been adopted or experienced. In contrast, acceptance includes a behavioural or reactive connotation. Since most ARAS and OBIS have not been implemented yet, it would be therefore more appropriate to use the term “acceptability” in reference to assistive systems for PTWs.

1.2. Focus-group Interviews

The data collection of this study was carried out in two stages. Firstly, focus group interviews have been conducted in Austria and Germany. With the results at hand, the online survey questions concerning situations in which assistive systems might be helpful were selected.

Group discussion is a method of empirical social research which focuses on thematic statements of a group and communication within a group (Webb & Keverin, 2001 [16]). Four focus group interviews (FGIs) lasting between 2 – 2,5hrs were conducted with groups of 7 and 8 motorcycle riders: two in Austria with commuters and recreational riders which were members of a motorcycle club and two in Germany with engineers, scientists and/or motorcycle riders of the BASt (Bundesanstalt für Straßenwesen). These targeted conspicuity related systems. In addition the FG-interviews based on experiences from interviews conducted previously with riders and focused on behavioural and safety issues in 9 European countries (in Austria, Czech Republic, Great Britain, Finland, France, Germany, Greece, Portugal and Spain); The interviews inquired about general familiarity with assistive systems, riders’ experiences with assistive systems, perceived advantages and disadvantages of assistive technologies for PTWs, and also their potentially positive and negative aspects (as many of the systems are not yet commercially available for PTWs). The discussions focused primarily on (ABS), Traction control system (TCS), Intelligent speed adaptation (ISA), GPS navigation; also a few other less familiar assistive systems were commented on (e.g. advanced front-lighting system, vision enhancing systems, daytime running light, airbags, collision warning systems, Vehicle-to-Vehicle communication, following distance warnings, lane departure and lane keeping systems, curve warning systems, crash-notification systems, brake booster, tire pressure control system). Besides, critical and erroneous riding situations in which assistive systems could be helpful were discussed by means of illustrative pictures and short videos while the riders had to assess severity and frequency of this riding behaviour.

The participants of the focus group interviews had a fair general knowledge of assistive systems, particularly drawing on experiences with passenger cars. Their attitudes were rather negative towards most of the systems for the motorcycles. The results from the questions provided useful information about active and passive systems which are typically considered useful or less important for PTW riders.

1.3. Quantitative Questioning: Motorcycle rider profiling questionnaire (MOPROQ)

The results from the focus group interviews formed the basis for the quantitative inquiry of motorcycle riders within the three-part **Mo**torcyclist's **Pro**filing **Q**uestionnaire (MOPROQ). The survey was distributed to motorcycle associations in Austria, Czech Republic, Great Britain, Finland, France, Germany, Greece and Portugal through the participating partners of the 2BeSafe project (Lenné et al., 2011 [10]). The survey was online for 5 weeks and all together 6297 questionnaires in seven different languages were completed.

MOPROQ 1 focused on different subpopulations of PTW riders (e.g. commuters, sports riders) highlighting several factors including: motivations for using motorcycles; riding practices; attitudes towards risk and risky manoeuvres; personality traits. MOPROQ 2 was based on previous questionnaires (Chen, 2009 [5], Ulleberg & Rundmo, 2003 [14]) designed to explore the relationship between personality traits, characteristics and attitudes towards traffic safety and risky driving behaviours.

Part 3 of MOPROQ focused on the acceptability of assistive and informative systems. In this part four specific riding situations were identified where these technologies might be helpful:

- Braking (ABS) and
- stability (TCS) enhancing systems as they play a major role and might be helpful in loss-of-control incidents.
- Particular situation where the usage of crash avoidance systems might be useful (autonomous cruise control, lane keeping assistance, curve speed warning, intelligent speed adaptation, collision warning systems etc.)
- Particular situation in order to provide information about the acceptance of informative systems (e.g. GPS).

Apart from some differences in the motivations for riding a motorcycle across the cultures (e.g. 'riding bends' – which has a high motivation for Finnish-speaking respondents in contrast to English-speaking respondents; 'speed' as high motivation for Greek riders etc.) the rating of the systems varied in different countries, e.g. ABS was rated as most important system in the German and English survey, 'Night vision' was rated as most important in the French, English and Portuguese survey, Advanced front lighting system, e-call scored high ratings in all the surveys, the same goes for GPS except for the French survey.

The main limitations of the online-survey that could have affected the responses and the acceptance of systems included:

- the language of the survey (German, English, French, Finnish, Portuguese, Greek): riders could only participate if they were fluent in one of the languages
- online-tools: there was a bias towards leisure riders of motorcycles; the sample included few scooter and moped riders and/or commuters;
- the distribution: due to insufficient time the survey was online only for a period of five weeks;
- the qualitative data section: an open-ended part has been provided for feedback (because of repeated requests of the riders); but given the size of the sample open-ended section were only partly screened and coded.
- most respondents lacked direct experience with assistive systems listed in the survey because most of them are not yet commercially available (explanatory texts were given in the survey).

2. Data analysis procedure

Acceptance was operationalised using MOPROQ-3 variables that measure the assessment of assistive systems. The variables were used to create four acceptance indices; these served in turn for the analysis of acceptance clusters (Lenné et al., 2011 [10]).

First reliability analyses were computed for all variables addressing the acceptance of braking enhancing systems, traction control systems, distance warning systems and navigation systems in order to obtain four indices, representing an "acceptance index" for each system.

These indices were then used in two step cluster analysis. The cluster analysis classified the sample into two acceptance groups (clusters), based on the four indices. t-tests and cross-tabulations were used to assess which variables have an influence on the different acceptance of ARAS and OBIS (i.e. which variables differ between high- and low-acceptance clusters). The strength of associations between variables was measured using Cramer's V for categorical variables, and effect size correlation for continuous variables.

Demographic variables from MOPROQ-1 were cross tabulated with the acceptance clusters in order to determine to what extent these characteristics contribute to the acceptance of ARAS and OBIS. These included: age; marital status; riding frequency; usage of motorcycle; license type; motorcycle type; motivation for riding a motorcycle; perceived downside of riding; planning of longer trips; use of specific traffic lanes; riding practices; accident history; and total riding exposure in kms.

The variables from MOPROQ-2 were analysed using effect size correlation to determine how acceptance of assistive systems is influenced by safety attitudes, personality and risky riding behaviour. The specific factors included: traffic flow versus rule obedience; speeding; fun riding; anxiety; anger; sensation-seeking; altruism; normlessness; and risky riding behaviour regarding self-assertiveness, speeding and rule violations.

3. Results and findings of the study

6297 PTW riders (from A, AU, CZ, Fin, F, GER, GR, I, P, UK) completed the questionnaire. Nearly all respondents (93%) were male. The sample ranged in age from 15-71 years, although most were aged 21-60 years. Most of the respondents rode PTWs frequently (over 90% riding 1-7 days/week). The most common reported reasons for riding a PTW (see Figure 1) included fun (88%), commuting

(69%), trips (68%), shopping (40%). Riding motivation varied slightly between countries, possibly due to dissimilar traffic conditions and road rules.

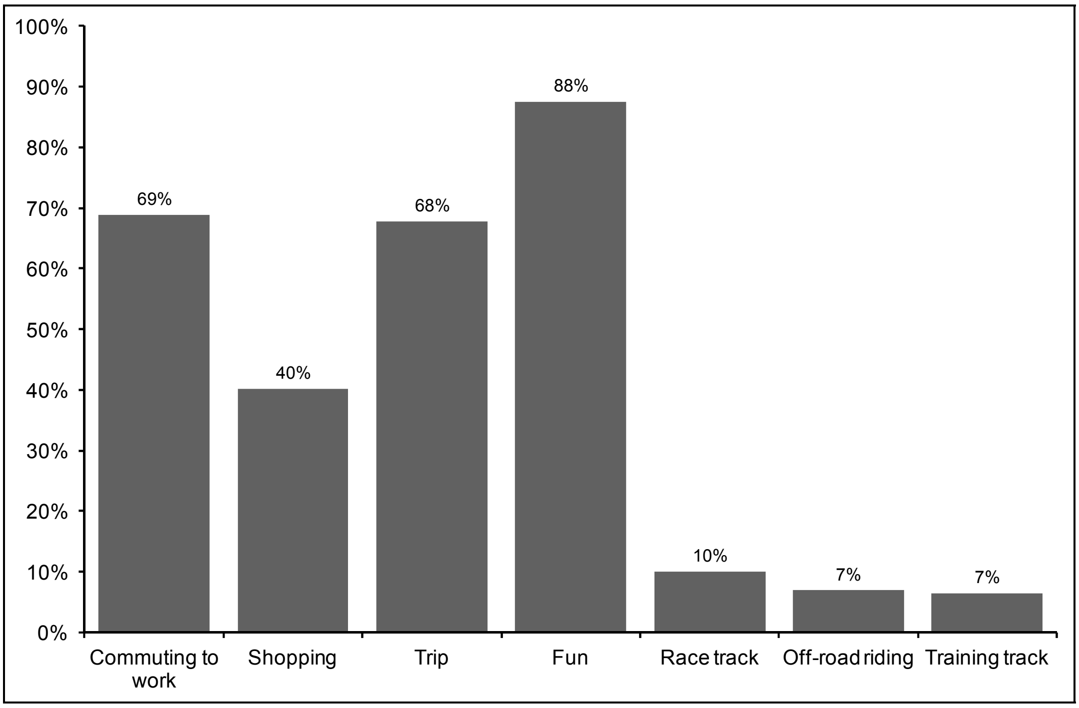

Figure 1: Reasons for riding a motorcycle, N=6297

The self reported common awareness of assistive systems was high with 90% reporting some degree of familiarity with each system studied (short explanatory texts for each system were given for the clarification). The systems with the least familiarity scores were curve speed warning, night vision, slipper clutch, advanced front-lighting system and vacuum servo. Unfamiliarity, however, does not necessarily entail the rejection of a system. The highest degree of awareness fetched systems that are commonly available, such as ABS and GPS and systems widely known or considered reliable from passenger cars.

Surveying the acceptability of systems, following findings emerged from the survey data:
The acceptability of systems depends on their function: rider acceptance towards informative systems (e.g. GPS, night vision) was higher than towards assistive systems that interfere with the riding task. Also systems that were perceived as more useful in emergencies, such as eCall, ABS or emergency brake assistance scored higher. There was consistently low acceptance of systems such as ACC, ISA and lane keeping assistant, because they might interfere with the riding task and/or were perceived to remove some of the rider's responsibilities (see Figure 2).
There is a distinct subgroup of PTW riders who ride primarily for fun or leisure and this group displays lower acceptance of assistive systems. This finding is in line with earlier work of the 2beSafe project which identified two riding populations: "sports riders" (riding for fun) and "commuters" (riding for practical purposes). Sports riders, who have lower overall acceptance of assistive technology, are particularly opposed to systems that interfere with the riding task.

Within the sample two subgroups were identified; these groups are referred as “low acceptance” and “high acceptance” groups, based on their universal opinions and attitudes towards the four types of assistive systems: braking enhancing systems; traction control systems; distance warning systems; and navigation systems. The high acceptance group showed significantly greater acceptance of all systems examined in the survey, with the greatest differences observed for TCS, ABS and related braking technologies (Combined braking systems, Emergency brake assistance), curve speed warnings, collision warnings and airbags.
Despite the variations in levels of acceptance, the overall acceptance was relatively low for all systems, especially when compared to the levels of acceptance for comparable systems available for passenger cars.

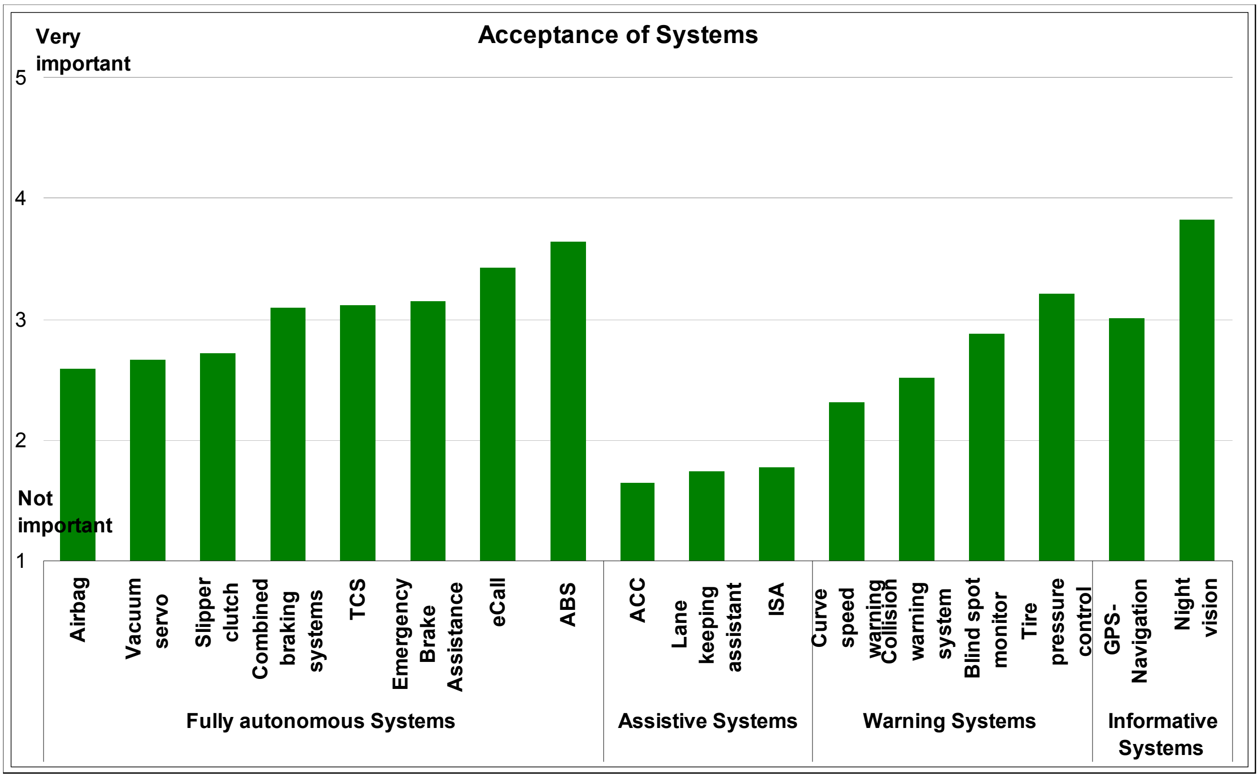

Figure 2: Acceptability of different systems (means, 5 = this system is important for enhanced riding safety, 1 = this system is not important for enhanced riding safety)

3.1. Barriers to acceptance of assistive technologies for PTWs

The respondents listed following concerns, sorrows and desires regarding the acceptance of ARAS and OBIS:

- Training and teaching of riding skills. The major part of the respondents, particularly the more experienced riders, stressed the importance of more comprehensive and regular rider training, instead of developing new assistive systems in order to improve PTW rider safety. Concerns were raised that assistive systems may even have contra-productive effects for the riders’ training, because riders might over-rely on the system and as a consequence, they will never learn, or will lose, the technical riding skills that help them to avoid and resolve dangerous situations. In their opinion this especially applies to novice riders and riders who have not ridden a motorcycle for a longer period of time. However, the assumptions of the effectiveness of motorcycle rider training are not based on objective evidence.

- Vehicle control. A strong attitude of reluctance towards systems which actively interfere in the riding task and remove the responsibility of the rider to control the PTW has been observed (e.g. ISA, ACC, lane keeping assistance). This is a major barrier because it limits perceived usability and satisfaction and has serious implications that relate to system reliability: if riders fear that a system might fail or not be reliable, they won't be willing to pay extra money for it. These views might be critically questioned though, as many motorcycle riders do not have direct experience with assistive systems (most of them are not available yet). However the current study as well as earlier studies (e.g. Cairney & Ritzinger, 2008 [4]) highlighted the importance of such arguments and they must therefore be taken seriously in order to reach acceptance. More effort has to be made towards understanding of training and skill acquisition, and into the identification of systems which can offer the best benefit for PTW riders.
- Technical maturity and reliability. Even though some of the systems are perceived as potentially beneficial, such as e.g. ABS, emergency brake assistance or traction control, some riders expressed their concerns regarding the technical maturity and reliability of the system. This lack of trust in the system affects their willingness to accept it.
- Cost argument and applicability. Most of the respondents fear additional costs in connection with assistive systems, especially the technically more sophisticated ones. They might either increase the price of the motorcycles (especially of small scooters and mopeds) or the optional retrofitting of assistive systems will incur additional costs that are too high compared to the original costs of PTWs. Not least, it is considered impractical to fit assistive systems on PTWs retroactively.
- Motivation of industry. Many motorcycle riders were critical towards industry motivations. They doubted that manufacturers when developing assistive technology have genuine safety concerns for riders in mind but rather the potential profit of their company.
- Behaviour of other road users. Respondents expressed that many of the dangers that PTW riders face derive from erroneous behaviour of other road users. They criticised that too much focus is put onto the development of assistive systems as a means of improving PTW rider safety instead of focusing on interaction, awareness and understanding between different road user groups. They are questioning the safety benefit of assistive systems that focuses solely on the PTW riders (and associated restrictions for motorcycle riders) without considering the behaviour of other traffic participants.

4. Conclusion

The study aimed at examining factors that affect PTW riders' acceptance of ARAS and OBIS, collectively referred to as "assistive systems". The results of a large-scale international survey revealed that both general and system-specific factors influence acceptance of assistive systems.

Viewing the attitudes towards the assessed systems, the sample was divided into two groups: a low and a high acceptance group. Main differences between these groups represented their attitudes towards riding in general and their respective riding practices. The high acceptance group perceived a greater downside to riding, but were also more likely to engage in high-risk riding behaviours such as riding on the hard shoulder and speeding. In general, systems providing obvious benefits, such as eCall, were assessed comparatively more positive than those that interfere with the actual riding task. Finally, results suggest a lower acceptance of PTW assistive systems among motorcycle riders compared to the acceptance of equivalent systems in passenger cars among drivers. This is likely because of the substantial differences between riding and driving, both in terms of motivations for riding, which affect willingness to accept interference from assistive systems, and physical differences between PTWs versus cars, which influence the practicality, effectiveness and affordability of assistive systems for PTWs relative to cars. The results of the survey suggest there is a large potential how to increase acceptance, either through changing the riders' attitudes towards the technology or by changing the technology itself. Especially the qualitative data showed that PTW riders estimate the effects of measures enhancing riding skills and riders training (especially for risky riding situations such as slippery roads, surfaces, curves, visibility conditions etc.) as more sustainable for the safety of motorcyclists, especially of novice riders, than assistive systems. Systematic promotion and training of riding skills and teaching how to understand specific conditions and behaviours of other road users can provide significant improvements in this regard. To avoid uncertainty and potential miscommunication between road users, another focus has to lie on enhancing interaction and communication skills in traffic.

Due to the fact that the recruitment and distribution process of this survey was based on topic-related internet forums and addressed specific motorcycle associations, the representativeness of the results is obviously limited. Therefore, a further research must attempt to gather a more representative sample of riders.

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