Acceptability of rider assistive systems for powered two-wheelers

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Abstract

There has been limited development of advanced rider assistance systems and on-bike information systems for powered two-wheelers (PTWs), even though research suggests population-wide deployment of assistive systems could significantly reduce PTW crashes. This study aims to understand general and system-specific factors that are likely to influence acceptability of PTW assistive systems, including barriers that may prevent uptake and proper use of systems, through a large-scale survey amongst European riders. The survey was available in seven languages and attracted 6297 respondents. Respondents were frequent riders, who rode primarily for leisure purposes and had high awareness of assistive systems. Cluster analysis revealed two groups based on overall acceptability of assistive systems. The moderate and low acceptance clusters differed in terms of riding practices, risk perception, attitudes towards rule breaking, and some personality traits. Overall acceptance was low, but riders who perceive greater risk in riding display higher acceptability. Acceptability was highest for systems that do not interfere with the riding task, are well-known and/or considered reliable (e.g., night vision, ABS, eCall, advanced front-lighting system). In general, riders believe that existing safety equipment (e.g., helmets, protective clothing) is more reliable, provides greater resistance, and is considerably cheaper than more sophisticated assistive technology. Riders believe that innovations should focus on protective equipment, since they believe crash prevention is better addressed through rider training. Finally, riders felt there should be more emphasis vehicle tyre condition and tyre pressure control systems were identified as potentially helpful.

1. Introduction

The development of assistive systems for powered two-wheelers (PTWs; motorcycles and mopeds) is an emerging issue. Whereas safety-enhancing assistive systems for other vehicles, such as passenger cars and heavy goods vehicles, are now widespread in many countries there has been limited development of equivalent systems for PTWs: advanced rider assistance systems and on-bike information systems (Bayly et al., 2007). Large-scale deployment of effective assistive systems has the potential to reduce the prevalence and severity of PTW crashes, which is valuable given that PTW riders are over-represented in fatal and serious injury crashes in most countries (Baldanzini, 2010; European Commission, 2012; NHTSA, 2009; WHO, 2004).

In order to realise the potential safety benefits of PTW assistive systems, and alongside demonstrating the technologies' effectiveness, it is essential to identify barriers that may prevent system uptake and use. That is, researchers need to understand whether assistive systems are, or could become, acceptable to PTW riders. It is counterproductive, both financially and from a safety perspective, to invest in developing new technologies if the systems are never purchased or if they are purchased but never used (van der Laan et al., 1997). The current study aims to understand factors that influence acceptability of PTW assistive systems by conducting a large-scale international survey of PTW riders.

1.1. Overview of Acceptability and Acceptance

Acceptability refers to "whether the system is good enough to satisfy all the needs and requirements of the user" (Nielsen, 1993, p.24). Some researchers differentiate between acceptability and acceptance (Schade & Schlag, 2003): acceptability is a prospective judgement regarding a system that has not yet been adopted or experienced, whereas acceptance describes retrospective attitudes towards an existing system. Since most PTW assistive systems are not yet implemented, or are not in widespread use, it is appropriate to use the term "acceptability" for most systems.

Various models have been proposed to explain and predict acceptability, which incorporate several common themes. These include problem awareness, usability, utility, affordability and social acceptability. *Problem awareness* is necessary for developing positive attitudes towards a proposed solution (Schlag & Teubel, 1997). *Usability* or *ease of use* refers to the potential for users to successfully learn to use the system with minimal effort; whereas *utility*, *usefulness* and *effectiveness* describe whether the system achieves its described functionality (Davis, 1989). Utility and usability may conflict: a system might achieve its intended function in such a way that the user cannot efficiently interact with the system (i.e., high utility, low usability). *Affordability* refers to whether users are financially able and willing to buy the system. Finally, *social acceptability* recognises the broader social issues that affect system users (Nielsen, 1993). For example, riders' views on how systems should be deployed and whether it is safe or desirable for a system to over-ride their control of the vehicle.

Recently Vlassenroot et al. (2010) developed a model of acceptability that integrates the most relevant predictors of acceptability as indicated by previous research. As shown in Figure 1, this model distinguishes between general and system-specific indicators of acceptability. *General indicators* refer to overall context in which the system operates, whereas *system-specific indicators* refer to specific characteristics of a system. This model of acceptability was adopted for the current study.

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1.2. Assistive Systems for PTWs

Assistive systems for PTWs include intelligent transportation systems (ITS) and other safety systems that have been developed, or are currently in development, for PTWs. A comprehensive description of PTW assistive systems is provided in the benchmarking database component of the EU Saferider Project (Pauzié & Guillot, 2008); however, Table 1 here provides a brief overview of assistive systems included in the current study. These technologies combine aspects of advanced information processing, communications, sensing and control technologies to produce systems that are capable of addressing various road transportation problems; in particular, improving road safety and traffic conditions, integrating road users in the transportation system and enhancing rider comfort. Systems vary in functionality, from systems that merely provide information (e.g., navigation systems) to systems that temporarily take over part of the riding task (e.g., adaptive cruise control).

There are a number of ways to classify assistive systems, for example, differentiating the timing or extent of intervention. One common distinction, which applies to risk-mitigating systems, is between systems that activate pre-, during and post-crash (e.g., Bayly et al., 2006). Active pre-crash systems detect a potential crash (e.g., high travel speed approaching an intersection) and act prior to it. Some (but not all) of these systems can reduce the likelihood or severity of crashes. Active safety systems include crash avoidance systems, stability and braking enhancing systems, speed limiting systems, visibility enhancing systems, and driver monitoring systems. Passive and post-crash systems are crash mitigating systems that aim to minimise the negative effects either during (e.g., airbags, smart restraints) or immediately after the crash (e.g., automatic crash notification/eCall). In addition to the active/passive distinction, it is possible to differentiate systems according to their level of automation or intervention (e.g., Shladover, 1995). *Informative* systems simply provide visual or auditory information; *warning* systems transmit visual, auditory or haptic alerts; *intervening* systems take over part of the riding task in critical situations; and *fully automated* systems operate without contribution from the rider and cannot be over-ridden.

To date, few assistive systems have been developed specifically for PTWs (Bayly et al., 2006; Pauzié & Guillot, 2008). Many systems are developed for four-wheeled vehicles, with some systems then adapted for two-wheelers. The distinction between two- and four-wheeled vehicles is important due to fundamental differences between these vehicle types, which pose technical challenges for designing and implementing assistive systems (Biral et al., 2010a). PTWs are light, single-track vehicles and are hence less stable than cars; they exhibit large roll angles, high acceleration and deceleration rates, and perform abrupt manoeuvres. These distinct movement dynamics make it more difficult to estimate vehicle lane position for PTWs. PTWs are also smaller than passenger vehicles and there is no separation between the rider and road environment, meaning there is less space for installing equipment and less power available.

Some PTW associations, such as FEMA, ACEM and the US Motorcycle Safety Foundation, have advocated for the development of assistive systems that directly address rider safety. Particular systems suggested for priority development and promotion include collision warning and collision notification systems (Motorcycle Safety Foundation, 2000), daytime running lights, anti-lock braking systems and combined braking systems (FEMA, 2006), and vehicle-to-vehicle communications, which may lessen the incidence of conspicuity-related crashes (ACEM, 2008).

1.3. Previous research on acceptability of PTW assistive systems

Most prior acceptability research has focused on assistive systems for passenger cars. Acceptability research regarding PTW riders has focused on a limited range of systems including: intelligent speed adaptation (ISA); anti-lock braking systems (ABS); automatic crash notification; and collision avoidance systems. Of these systems, ISA has been studied in the most depth. Existing acceptability research is summarised below.

1.3.1. Intelligent speed adaptation

ISA systems vary in functionality: *alerting* (warning) ISA systems provide an alert when riders exceed the posted speed limit, *limiting* (intervening) ISA systems interact with vehicle systems to remove the rider's ability to exceed the speed limit, and *supporting* ISA systems provide a tactile warning (e.g., throttle resistance) when exceeding posted speed limits. Most acceptability studies differentiate between ISA variants, since attitudes are typically more negative towards limiting systems.

Cairney and Ritzinger (2008) conducted focus groups in Victoria, Australia, to assess the acceptability of ISA, ABS and automatic crash notification to riders and road safety experts. They found mixed attitudes towards ISA: few riders believed it would improve safety, although safety experts believed that ISA would reduce speeding. Some riders regarded ISA as unnecessary because they are already aware of their own speed, and they suggested that ISA could negatively affect safety by reducing riders' speed awareness. Both riders and experts believed there was potential for ISA to distract riders. The primary perceived benefits of ISA were that it could help avoid speeding fines and that it may incorporate a GPS-based navigation system, but overall ISA was not considered good value for money.

Simpkin et al. (2007) examined acceptance of alerting and active supporting ISA in a group of experienced riders who completed test-track trials using both systems. The alerting ISA provided the rider with a visual display of the current speed limit and used a combination of visual, auditory and haptic alerts when riders exceeded the speed limit. The supporting system provided the current speed limit and used a counter-action on the throttle, which was not strong enough to prevent the rider from keeping the throttle open. Overall, riders indicated dissatisfaction with supporting ISA and were unwilling to adopt the system. Attitudes were slightly more favourable towards alerting ISA but the system was perceived as reducing joy, hindering overtaking, increasing irritation and the rider's sense of being controlled. ISA was considered to be most suitable for young riders, novices and speeding offenders (Simpkin et al., 2007). Experience using supporting ISA improved perceived system usefulness but not satisfaction. This suggests that although riders could see the potential benefit of supporting ISA, they did not feel comfortable with its fundamental function of limiting their speed. The major barriers to using ISA included irritation, distraction, safety concerns regarding throttle closure on corners, reduced power and the need to push buttons in a dangerous situation.

There has been opposition to ISA amongst rider groups. For example, in 1999 the International Riders' Public Conference in France adopted a joint resolution setting out a position rejecting speed limiting on PTWs and arguing that ISA threatens safety in situations where accelerating is the only option to avoid a collision. FEMA agreed with this position, adding that ISA must allow the rider to retain complete control of their vehicle. Negative attitudes towards ISA persist; in a recent study by SMC (Sveriges MotorCyklister; FEMA's Swedish branch), less than 10% of riders expressed positive attitudes towards ISA systems (Nordqvist & Gregersen, 2011). Two-thirds expressed negative views regarding ISA and almost 60% expressed concern that riders would rely too much on technology. These figures starkly contrast levels of ISA acceptability among car drivers; results vary across studies, but acceptance is generally high with over 45% of drivers expressing positive views towards ISA and a minority expressing strongly negative views (Regan et al., 2006).

1.3.2. Advanced braking systems

ABS are already commercially available on some PTWs including touring motorcycles, sports vehicles and some scooters. It has demonstrated potential to improve braking behaviour and hence reduce some PTW crash types (Rizzi et al., 2009; Teoh, 2011; Toyofuku et al., 1994). Cairney and Ritzinger (2008) investigated experts' and riders' opinions of ABS. They found expert opinion was very positive regarding ABS, as respondents noted potential safety benefits from assistance with braking manoeuvres, particularly in emergencies. Rider opinion was divided: while some agreed that ABS would improve safety, many worried that the system would undermine the development of braking skills or operate in an unexpected manner, disrupting the rider's braking routine. Some argued a skilled rider could brake more effectively than system-controlled braking manoeuvres; however, respondents noted that most riders do not attain this skill level and even highly skilled riders experience difficulty in performing emergency braking manoeuvres. Perceptions of ABS affordability depended on the value of the PTW; it was considered reasonable value on expensive motorcycles, but unrealistically costly for smaller vehicles.

A recent Swedish study of riders' attitudes towards safety equipment found that most riders (82%) would choose an ABS-equipped vehicle when purchasing their next PTW (Nordqvist & Gregersen, 2011). In addition, one-third of riders would select combined brake systems (CBS) and one-fifth would select traction control systems on a new vehicle. When buying a second-hand vehicle, 73% would require ABS and 27% would require CBS. Similarly, in a US telephone survey 58% of respondents believed that ABS would help a rider stop in a safe manner and 54% indicated that they would obtain ABS on their next motorcycle (McCartt et al., 2011).

1.3.2. Automatic crash notification

Only one previously published study has investigated the acceptability of automatic crash notification, using focus groups to survey riders and road safety experts (Cairney & Ritzinger, 2008). This research found that both riders and experts expected automatic crash notification to decrease crash response times, particularly in rural areas. Riders noted that automatic crash notification effectiveness depends on the communication system used; much recreational motorcycling occurs in remote and mountainous areas, where cellular telephone coverage is incomplete. Riders considered a cancellation function necessary to prevent false alarms when the system was activated in error. Automatic crash notification was perceived as good value for people who need it, but riders disliked the prospect of paying ongoing subscriptions.

1.3.4. Collision avoidance systems

Recently researchers have begun to investigate riders' attitudes towards collision avoidance systems. There are several types of collision avoidance systems, such as frontal collision warning, intelligent curve warning and intersection warning systems.

Montarini et al. (2011) investigated acceptance of a frontal collision warning system as part of a closed circuit track test. The system received relatively high scores for supportiveness, comprehensibility, exclusivity, novelty and innovativeness (above 6/10), with the lowest ratings being for clarity and predictability (3.3/10). Nine of the 10 riders tested expressed a desire to have the system on their motorcycle and six indicated that they would always have it active. Most riders were willing to pay up to €250 for the system, but the estimated system cost was much higher.

Riding simulators have been used to evaluated intelligent curve warning systems and intersection warning systems. Biral et al. (2010b) tested an intelligent curve warning system that transmits visual and haptic warnings when large differences between threshold and monitored accelerations are detected. System use resulted in improved riding behaviour but received mediocre usability ratings (Montanari et al., 2011). Again, most riders were willing to pay up to €250 for the system but only 5 of the 10 riders reported they would leave the system on at all times (Montarini et al., 2011). Acceptance varied depending on the specific interface: transmitting warnings via the throttle was perceived as less desirable than transmitting warnings using a haptic glove (Huth et al., 2012). In another evaluation, for an intersection warning system using the same interfaces, acceptance was also higher for glove warnings compared to throttle warnings (Huth et al., 2011). Specifically, most riders were willing to have the glove system but fewer than half wanted the throttle warning. No rider was willing to pay more than €500 for either the intersection warning system or the intelligent curve warning system.

1.4. The Current Study

Assistive systems are not fitted as standard PTW features; most ITS and assistive systems are prototypes that are currently being tested in laboratories. As such, most research has been performed at a rather elementary level and with small sample sizes. In addition, there is little research examining acceptability of PTW assistive systems and factors that facilitate or obstruct acceptance. Most previous research has focused on only a few assistive systems and much of it was conducted several years ago. There is therefore a need for contemporary, more comprehensive research in this area: technical developments are being made at such a rate that the earlier research could not be expected to capture current systems and, when the earlier research was done, many riders would not have been aware of them and thus could not give a well-informed opinion. The current study aims to understand general and system-specific factors that influence acceptability of PTW assistive systems amongst European riders. Acceptability was measured using an online survey, which was distributed via several international rider organisations. General factors were explored by examining characteristics (e.g., motivations for riding, safety attitudes, demographic variables) that predict overall levels of acceptability. System-specific factors were examined by comparing levels of acceptability between systems (Vlassenroot et al., 2010).

2. Method

2.1. Participants

The survey attracted 6297 respondents from over 10 countries; Table 2 shows demographic information by country of residence. Participants were recruited online, primarily through FEMA and its member organisations.

2.2. Materials

2.2.1. Survey administration

The survey was administered online using SoSci survey - der onlineFragebogen (www.soscisurvey.de) and was available in seven languages: Czech, English, Finnish, French, German, Greek and Portuguese. Although recruitment was primarily through FEMA, the survey was freely available to anyone and accessible for a four-week period.

2.2.2. Survey content

The survey consisted of the three-part Motorcyclists' Profiling Questionnaire (MOPROQ), which was developed for the EU 2-Be-Safe project. MOPROQ-1 describes demographic characteristics, riding practices and motivations; MOPROQ-2 explores the relationship between personality characteristics, risk attitudes and riding behaviour (Bellet et al., 2011); and MOPROQ-3 assesses acceptability attitudes (Lenné et al., 2011).

MOPROQ-1 was designed to assess whether there exist different subpopulations of PTW riders (e.g., commuters vs. recreational riders) who differ in riding practices and motivations. The questionnaire consists of 40 closed questions and 32 open questions in four categories: (i) *socio-demographic data*, e.g., age, sex, type of PTW; (ii) *motivations for riding*, e.g., time saving, fun, speed, freedom; (iii) *riding practices,* e.g., annual exposure, risky riding manoeuvres, attitudes towards speed; and (iv) *individual accident history*, e.g., number and severity of accidents.

MOPROQ-2 was adapted from previous questionnaires that explore the relationship between personality traits and safety attitudes (Chen, 2009; Ulleberg & Rundmo, 2003). The questionnaire contains 30 items in three categories: (i) *personality*, e.g., anxiety, sensation seeking, altruism; (ii) *safety attitudes*, e.g., traffic flow, rule obedience, speeding; and (iii) *risky behaviours*, e.g., speeding, violations. All items use a 5-point scale from 1 (Not agree, Never) to 5 (Totally agree, Very often).

MOPROQ-3 contains five subsections. The first four subsections provide a description of critical riding situations, together with a description of a specific assistive system that could be helpful in that situation. The four assistive systems examined are braking enhancing systems, traction control, distance keeping and navigation. Respondents are asked to rate their agreement with statements regarding the advantages (e.g., "Such a system would support the riding task") and disadvantages (e.g., "Such a system leads to dangerous situations") of each system on a 5-point scale from 1 (I do not agree) to 5 (I agree totally). Higher levels of acceptability are indicated by high agreement with statements regarding advantages and low agreement with statements regarding disadvantages. Respondents were also provided with a brief list of potential modifications to each system and asked to indicate their extent of agreement with each.

The fifth and final MOPROQ-3 subsection provides a descriptive list of 18 assistive systems. Respondents are required to indicate their perceived importance of each system. Higher acceptability is indicated by higher importance ratings. This subsection included an option for "I don't know the system" to assess respondents' awareness of assistive systems.

2.3. Data analysis

Statistical analysis was conducted using SPSS. Two-step cluster analysis was used to reveal groupings of respondents based on overall acceptability of assistive systems. The acceptability clusters were based on four acceptability indices, based on attitudes towards the four assistive systems examined (braking enhancing systems, traction control, distance keeping, navigation). Cross-tabulations and *t*-tests were then used to assess which variables predicted overall acceptance of assistive systems. Given the large sample size, statistical significance is not a reliable indicator of meaningful effects. Consequently, results are reported in terms of effect size correlation (*r*) for scale variables and Cramer's *V* for categorical variables. Both are measures of association that range from 0 to 1: .1 indicates small associations; .3 moderate associations; and ≥.5 large associations. Comparisons with effect sizes below .1 were omitted due to space restrictions.

3. Results

3.1. Descriptive statistics

The largest proportion of respondents was from the United Kingdom, followed by France, Portugal and Greece (see Table 2). Australia was the only non-European country with a substantial number of respondents. Nearly all respondents were male (93%). The full age range was 15-71 years, with most respondents (75%) were aged between 31-60 years.

Riders in the sample reported a high level of PTW use: 66% rode at least 3 times per week and less than 10% rode less than once per week. The most common reasons for riding reported were personal enjoyment (88%), commuting (69%), trips (68%) and shopping (40%).

Respondents indicated high awareness of assistive systems; over 90% were aware of each assistive system. Generally, respondents reported slightly higher awareness of systems that are already widely available for PTWs, such as ABS (98%) and GPS (99%), with the lowest awareness levels for curve speed warning and night vision (91%).

3.2. Acceptability indices

Acceptability indices were calculated for four systems: braking enhancing systems (14 items); traction control (15 items); distance keeping (16 items); and navigation systems

(13 items). Indices were calculated using scale items rating agreement with the advantages and disadvantages of each system. Negative statements were reverse-coded. Cronbach's alpha (α) was used to assess scale reliability and items with low reliability were deleted. The final acceptability indices used 12 items for braking enhancing systems (α = .906), 14 items for traction control (α = .912), 12 items for distance keeping (α = .861) and 8 items for navigation systems (α = .868). The acceptability indices comprise a score between 1 and 5 for each system, where 1 indicates low acceptability and 5 indicates high acceptability.

3.3. Cluster analysis

Two-step cluster analysis revealed two clusters of respondents, which were labelled *low acceptability* and *moderate acceptability*, based on the four acceptability indices (see Table 3). The model summary indicated acceptable separation between clusters (cluster quality: SC >.5).

Table 4 summarises the acceptability of each assistive system, overall and by cluster. All systems showed moderate to large differences in acceptability ratings between clusters. Night vision had the highest acceptability rating and was the only system to achieve a positive acceptability rating (>3) among the low acceptability cluster. Curve speed warning, ISA, lane keeping assistant and adaptive cruise control had the lowest acceptability, with mean ratings <3 for the moderate acceptability group.

3.4. Cluster differences: MOPROQ-1 (demographics and riding practices)

The only demographic variable that differed between clusters was age. Riders in the low acceptability cluster were on average 3.3 years older than riders in the moderate acceptability cluster, $t(5011.6) = 10.61$, $p < .0005$, $r = .15$.

Clusters differed in their motivations for riding and perceived downside of riding. Riders in the moderate acceptability cluster were more likely to report riding bends (45% v. 32%, $V = .13$) and acceleration (45% v. 29%, $V = .15$) as motivations for riding, whereas riders in the low acceptability cluster were more likely to report cost advantages (48% v. 33%, *V* = .15) and CO_2 reductions (30% v. 17%, *V* = .15) as motivations. Riders in the moderate acceptability group were also more likely to report risk (78% v. 22%, *V* = .26) and fatigue (12% v. 5%, *V* = .12) as downsides to riding. Riders in the low acceptability group were more likely to believe that being a motorcyclist makes them a better car driver (94% v. 84%, *V* = .14).

Riders in the low acceptability cluster reported that they less frequently engaged in several risky riding practices including riding on the hard shoulder to avoid slowing down behind cars (*V* = .28), overtaking vehicles on the wrong side (*V* = .16), filtering in urban traffic (*V* = .13), filtering on highways (*V* = .10), riding down a one-way road in the wrong direction (*V* = .121), or riding in restricted areas including painted median strips (*V* = .19), sidewalks (*V* = .15), bus lanes (*V* = .17) and bicycle lanes (*V* = .10). Riders in the low acceptability group also reported lower annual exposure (*V* = .29): most riders in the low acceptability group reported travelling between 1,001-10,000 km per year (82%), whereas most riders in the moderate acceptability group reported travelling between 5,001-30,000 km per year (71%).

3.5. Cluster differences: MOPROQ-2 (personality and risky attitudes)

Several personality and attitude variables showed small to moderate relationships with cluster membership (see Table 5). Riders in the moderate acceptability group reported higher scores for fun riding, speeding and inappropriate overtaking manoeuvres. This group also reported higher levels of worry, upset and fear. Other personality variables showed little or no difference between clusters (e.g., concern for others, *r* = .03), which suggests that the clusters are differentiated on riding-specific attitudes rather than general personality traits.

3.6. Cross-cultural differences in acceptability

Absolute ratings of acceptability varied across countries, $F(9,5489) = 386.56$, $p < .0005$, $\eta_p^2 = .39$. Overall acceptability, averaged across all systems, was highest in Portugal ($M = 3.76$), Greece ($M = 3.67$) and Austria ($M = 3.59$), and was lowest in Czech Republic ($M = 1.76$) and UK ($M = 2.12$). Despite this variation, relative rankings of systems were similar across countries (see Table 6). In every country the three lowest-ranked systems were ISA, lane keeping assistant and adaptive cruise control. The four systems with the highest overall acceptability were night vision, ABS, advanced front-lighting system and eCall, and in all countries except Germany at least three of these four systems ranked in the top four.

3.7. Riders' concerns regarding assistive systems

Open-ended survey questions allowed respondents to raise issues that were not otherwise addressed. These responses were analysed qualitatively and the main themes regarding assistive systems are summarised below.

3.7.1. Rider training

Respondents repeatedly mentioned that they considered rider training fundamental in determining rider safety. Riders perceived the purpose of training as providing skills to react appropriately in poor road conditions (e.g., wet roads, uneven ground). This is perceived as particularly crucial for novice riders. It was suggested that riders should receive education regarding technical functioning and specific characteristics of their PTW, regardless of whether the vehicle is fitted with assistive systems. Rider training was suggested as appropriate at several stages: prior to licensing; mandatory refresher courses, which could occur at fixed time periods (e.g., annually) or on specific milestones (e.g., after periods of not riding); training for at-fault crash-involved riders; and training for high-power vehicles.

In addition for rider training, it was suggested that all road users should receive training aimed at fostering respect and tolerance for other road users. There was a perception that helping car drivers understand the perspectives of motorcyclists, and vice versa, could improve road safety (i.e., drivers would have greater awareness of hazards for motorcyclists, which could promote more cautious behaviour).

Overall, many riders appeared to place higher importance on rider training than assistive systems. There is a perception that assistive technologies may lead to careless or lazy riding and they do not improve understanding of vehicles' technical limitations. If assistive systems are used, riders must be provided with detailed information about their functioning to ensure that riders understand how the system works.

3.7.2. Control and personal responsibility

Riders disliked the idea of compulsory systems, particularly systems which they believe will remove control from riders. This insistence on control and personal responsibility appears linked to the motives for riding PTWs. Many respondents stated that whereas car driving is usually done for necessity, riding a PTW is a deliberate choice. Reasons vary but include practicality, personal preference and enjoyment. Given that riding is a choice, many riders have already factored in the risks. As such, when considering assistive systems, riders are focused not only on safety but also the extent to which systems interfere with riding. One crucial aspect for increasing acceptance is to include the option to temporarily disable the system. This is consistent with previous research, in which 50% of riders stated that they would turn off an assistive system at least part of the time (Montanari et al., 2011). Motorcycles may be ridden in a range of situations and some situations assistive systems may be less desirable, despite the fact that the systems themselves are technologically reliable.

Other concerns were expressed about the use of assistive systems. It was believed that multiple assistive systems would be confusing, annoying and distracting (e.g., the rider might receive multiple warnings during a critical incident). There was also concern that use of assistive systems could lead to over-reliance on technology and ultimately degrade riders' skill levels. While riders conceded that some systems could provide benefits, they overwhelmingly believed that assistive systems would not solve the underlying problem and would simply reduce the seriousness of crashes.

3.7.3. System reliability

Reliability and trust in the system were highlighted as crucial for acceptance. If technologies do not work reliably this may confuse riders and could increase their workload by creating uncertainty.

3.7.4. Demand for motorcycle-specific systems

Riders expressed a need for any assistive systems to be developed specifically for PTWs. The main perceived danger for non-specific systems (i.e., developed for cars and adapted for PTWs) relates to differences in stability between single- and multi-track vehicles. This need is imperative due to the different movement capabilities and dynamics of passenger cars versus PTWs, as well as the distinct rider and driver characteristics. Further, research suggests that the same road situation is interpreted differently by motorcyclists compared to car drivers (Walker et al., 2011). Hence, cognitive incompatibility between these two groups results in different needs and requires distinct systems and/or system specifications. ABS and traction control were seen as potentially helpful if specifically developed for PTWs. In contrast, technologies like adaptive curve lights and following distance systems were perceived as only useful for multi-track vehicles.

3.7.5. Industry consultation

Riders expressed concern about being "left out" of industry and government consultations regarding development and implementation of new systems. Riders suggested that industry is not genuinely interested in safety, but rather motivated by selling costly new devices. In general, riders believe that existing safety equipment (e.g., helmets, protective clothing) is more reliable, provides greater resistance, and is considerably cheaper than more sophisticated assistive technology. Riders believed that innovations should focus on protective equipment rather than systems that prevent crashes, since they believe crash prevention is better addressed through rider training. Finally, riders felt there should be more emphasis vehicle tyres condition and routine tyre checks. Tyre pressure control systems were repeatedly mentioned as potentially helpful.

4. Discussion

The current study investigated factors that influence acceptability of assistive systems for PTWs, including barriers that prevent system uptake and use. The results represent the views of a large international sample of PTW riders. Overall acceptability was low to moderate for all systems. Two subgroups of respondents were indentified within the sample: the low acceptability group and the moderate acceptability group. The moderate group reported significantly higher acceptability for all assistive systems, with the greatest differences observed being for braking systems, traction control, curve speed warnings, airbags and collision warnings. Acceptability varied by system function: riders indicated greater acceptability of informative systems (e.g., GPS, night vision) rather than systems that interfere with the riding task. Acceptability was also higher for systems perceived as more useful in emergencies (e.g., eCall). There was low acceptability for adaptive cruise control, ISA and lane keeping assistant, which are perceived as lessening the rider’s responsibility. Although the sample was large, it was biased towards male motorcycle riders who are frequent riders and may disproportionately represent the views of riders who are particularly interested in issues surrounding PTW assistive systems. This potential bias should be kept in mind when interpreting the results.

4.1. General Indicators of Acceptability

Several variables were investigated as potential general predictors of acceptability. These included demographic variables, personality traits, riding practices and attitudes towards riding. Unsurprisingly, perceiving risk as a downside of riding was a significant predictor of overall acceptability of assistive systems, consistent with previous research suggesting that problem awareness is necessary for acceptability (Schlag & Teubel, 1997). Riders' self-reported annual exposure was also a significant predictor of acceptability. Although there was not a complete linear relationship, riders in the moderate acceptability group were more likely to report travelling over 10,000 km per year. This finding may reflect other characteristics such as motivations for riding and typical PTW usage.

The acceptability clusters differed in self-reported riding practices and risk attitudes. Interestingly, those who demonstrated low acceptability of assistive systems were less likely to report speed and riding in restricted areas or on the hard shoulder. There are two ways of interpreting this finding. First, taking the results at face value, it appears that riders who engage in more risk-taking behaviour also display higher acceptability of new safety technology, meaning the systems are likely to be adopted by those who most need them. However, given that the results are based on self-reported behaviour, it could be that riders who downplay the risks of riding and/or who believe their relative risk of accident is lower (e.g., compared to riders who they believe are less experienced or less skilled) have lower acceptability of assistive systems.

4.2. System-Specific Indicators of Acceptability

The results revealed some system-specific indicators of acceptability, indicated by the variation in acceptability between systems. The greatest levels of overall acceptability were for night vision, ABS, advanced front-light and eCall, while the lowest levels of acceptability were for ISA, lane keeping assistant and adaptive cruise control. Several attributes appear particularly influential in determining system acceptability: perceived usability/satisfaction; usefulness; effectiveness; and affordability. Overwhelmingly, riders objected to systems that interfere with their responsibilities as a rider, such as ISA and adaptive cruise control (perceived usability/satisfaction). Riders showed greater acceptability of systems that will provide obvious benefits in emergency situations, such as eCall (perceived usefulness). Riders expressed preference for established systems (e.g., ABS) that are well-known, considered technically mature and have demonstrated safety benefits (perceived effectiveness). Conversely, riders expressed concern that some systems, particularly those that reduce the rider's responsibility, may foster over-reliance and lead to de-skilling of riders, which would ultimate reduce safety. Finally, riders expressed concern that some systems may not be cost-effective for fitment on most PTWs (affordability).

General indicators of acceptability may influence the relative importance of system-specific indicators. For example, an individual's reasons for riding a PTW (general indicator) will influence the weight they put on different system-specific characteristics such as usability and satisfaction. The choice to ride a PTW is made for specific reasons, often including enjoyment of riding. As such, automating functions and reducing rider workload often has perceived negative effects such as increased boredom, which could lead to inattention-related incidents.

4.3. Barriers for Acceptability

There are several barriers to the uptake of PTW assistive systems, some of which relate to general issues and some of which relate to system-specific issues. Most relate to perceived effectiveness and usefulness, consistent with previous research (Cairney & Ritzinger, 2008).

The most influential general barrier is a focus on "skills over technology". Many riders, particularly more experienced riders, believe that support systems will inhibit and/or reverse the development of riding skills. This limits perceived usability and satisfaction and has implications regarding system reliability: riders are concerned that if systems fail they will not have the skills to respond appropriately. This argument also influences perceived value of technologies: riders will be unwilling to pay extra for ABS if they have received brake training that has a similar level of perceived effectiveness. Thus although riders showed moderate acceptability of ABS, they also believed novice riders should receive brake training to avoid over-reliance on ABS. Although the validity of the “skills over technology” view is questionable, it appears to be widespread and therefore represents a major barrier to the acceptability of assistive systems for PTW riders.

Cost is another highly relevant barrier since optional and retrofit systems are high-cost relative to the overall vehicle cost, especially smaller or second-hand PTWs. However, it is difficult to fully assess the link between affordability and acceptability without reliable knowledge the riding population’s socio-economic status and without knowing how assistive systems will be marketed in future. This limitation of the current study could be addressed in future work.

4.4. Implications and Recommendations

It appears that there may be potential to increase PTW riders’ acceptability of assistive systems, either through changing riders’ attitudes or by changing the actual systems. Most of the riders surveyed did not have direct experience using the assistive systems studied. However, many respondents expressed concern that systems would prompt over-reliance or “de-skilling”, particularly among learner riders, and there was a common view that rider training could be more beneficial than safety technology. This suggests that acceptability could be improved by educating riders about the benefits of assistive systems. While existing research in this area should be more widely publicised, there is a clear need for more empirical research investigating the respective benefits of both assistive systems and rider training, especially in direct comparison to each other, so as to provide robust evidence to guide these discussions.

There is reasonable evidence to suggest that riders will accept systems that they perceive as useful and effective. The current study found that drivers who perceive risk as a downside to riding also have higher acceptability of assistive systems, presumably because they perceive a need for improved on-road safety. In addition, the systems that currently have the highest levels of support include those that are more established and have greater exposure, such as ABS. It would be beneficial to conduct more extensive on-road research examining the effects of using assistive systems on PTWs. This seems particularly important given that a major concern among riders is that new systems will have negative effects on riding style and skills, and given existing research from passenger cars that indicates that many systems do in fact produce mixed safety benefits (e.g., Vaa et al., 2007).

Although it may be possible to improve the acceptability of some systems by changing riders' attitudes, it is apparent that other systems face widespread opposition for various reasons. Two aspects in particular should be considered when developing assistive systems for PTWs: *physical characteristics of PTWs*, since vehicle stability and size alters the effectiveness and cost-effectiveness of assistive systems for PTWs compared to cars; and *influence on riding style*, as some systems may require riders to change their riding style, which may lessen enjoyment or require further training.

Regarding the current study's finding that riders who have low acceptability of assistive systems report fewer risky riding practices, there are several implications. First, it suggests that safety campaigns promoting assistive systems should be customised to appeal to riders who perceive themselves as having lower risk of crashing. It may also be worth conducting further research to directly measure riders' behaviour. Because the current study assessed self-reported behaviour, it is possible that riders intentionally or unintentionally misrepresented their riding behaviour, or that they underestimated their needs for assistive systems due overestimating their abilities in risk awareness and risk management. This creates ambiguity when interpreting the results comparing clusters. Reliably measuring riders' objective behaviour would be extremely resource-intensive and would require instrumenting the riders' vehicles, preferably for an extended period of time. Even if feasible, it may be difficult to persuade riders who have low acceptability of assistive systems that they should allow researchers to instrument their PTW. Nevertheless, future research should examine riders' risk awareness and risk management in conjunction with acceptability in order to better understand the relationship between risk perception, risky behaviours and acceptability of assistive systems.

5. Conclusions

Based on the current study's findings, it appears that any attempt to make assistive systems compulsory will be met with strong resistance by PTW riders. There are several reasons for this including cost, perceived effectiveness, perceived usability and satisfaction. For example, eCall has relatively high acceptability and is perceived as useful, but riders would likely oppose its mandatory use because the perceived and established benefits are not sufficient to outweigh the system cost (see FEMA, 2011).

The current study revealed that both general and system-specific factors influence acceptability of assistive systems. In terms of general indicators, riders who perceive greater risk in riding and those who report engaging in riskier riding practices report higher acceptability for all systems. In terms of system-specific indicators, riders are more accepting of systems that provide obvious benefits, such as eCall, or systems that do not substantially interfere with riding. Overall, acceptability of PTW assistive systems is relatively low compared to equivalent systems in passenger cars (e.g., Regan et al., 2006). This is likely due to fundamental differences between riding and driving, both in terms of motivations for riding, which influence willingness to accept interference from assistive systems, and physical differences between PTWs versus cars, which influence the practicality, effectiveness and affordability of assistive systems for PTWs relative to cars.

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References

ACEM (Association des Constructeurs Européens de Motocycles). (2008, December). *A Safety Plan for Action*. Retrieved from http://www.acem.eu/media/d_SafetyPlanforAction_94993.pdf

Baldanzini, N. (2010, February). *Analysis of motorcycle crashes in the MAIDS database: Report on activities in Work Package 2*. Paper presented at the MYMOSA Workshop, Motorcycle and Motorcyclist Safety, Marie Currie Action Program, Amsterdam, Netherlands.

Bayly, M., Hosking, S., & Regan, M. (2007). *Intelligent transport systems and motorcycle safety* (Paper No. 07-0301). Paper presented at the 20th International Technical Conference on the Enhanced Safety of Vehicles (ESV), Lyon, France.

Bayly, M., Regan, M., & Hosking, S. (2006). *Intelligent transport systems and motorcycle safety* (Report No. 260). Melbourne, Australia: Monash University Accident Research Centre.

Bellet, T., Banet, A., Joshi, S., Turetschek, C., Risser, R., Spyropoulou, I., Rößger, L., Hagen, K., Carvalhais, J., Noriega, P., Leden, L., Rosander, P., Johanson, C., Underwood, G., Roebroeck, H., Delahaye, A., & Lenné M. (2011). *Risk perception: its contextual parameters, and its influence on PTW choices and riding behaviour* (2-Be-Safe Deliverable 8). Paris, France: 2-Be-Safe.

Biral, F., Lot, R., Sartori, R., Borin, R., & Roessler, R. (2010a, October). *An intelligent frontal collision warning system for motorcycles*. Paper presented at the Symposium on the Dynamics and Control of Single Track Vehicles, Bicycle and Motorcycle Dynamics, Delft, The Netherlands.

Biral, F., Da Lio, M., Lot, R., & Sartori, R. (2010b). An intelligent curve warning system for powered two wheel vehicles. *European Transport Research Review, 2*(3), 147-156.

Cairney, P., & Ritzinger, A. (2008). *Industry and rider views of ITS for safe motorcycling*. Paper presented at the 23rd ARRB Conference – Research Partnering with Practitioners, Adelaide, Australia.

Chen, C. (2009). Personality, safety attitudes and risky driving behaviours – Evidence from young Taiwanese motorcyclists. *Accident Analysis and Prevention, 41*, 963-968.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319-340.

European Commission (2012). *EU Transport in Figures: Statistical Pocketbook 2012*. Brussels, Belgium: European Commission. Retrieved from, http://ec.europa.eu/transport/publications/statistics/doc/2012/pocketbook2012.pdf

FEMA (Federation of European Motorcyclists' Associations). (2006, November). *Consultation paper: Saving [car drivers'] lives with daytime running lights.* Brussels, Belgium: FEMA.

FEMA (Federation of European Motorcyclists' Associations). (2011, March). *FEMA position paper on intelligent transport systems.* Brussels, Belgium: FEMA.

Huth, V., Lot, R., Biral, F., & Rota, S. (2011). Intelligent intersection support for powered two-wheeled riders: a human factors perspective. *IET Intelligent Transport Systems. 6*(2), 107-114.

Huth, V., Biral, F., Martin, Ó., & Lot, R. (2012). Comparison of two warning concepts of an intelligent curve warning system for motorcyclists in a simulator study. *Accident Analysis and Prevention, 44*(1), 118-125.

Lenné, M.G., Beanland, V., Fuessl, E., Oberlander, M., Joshi, S., Rößger, L., Bellet, T., Banet, A., Leden, L., Spyropoulou, I., Roebroeck, H., Carvalhais, J., & Underwood, G. (2011). *Relationships between rider profiles and acceptance of Advanced Rider Assistance Systems* (2-Be-Safe Deliverable 9). Paris, France: 2-Be-Safe.

McCartt, A.T., Blanar, L., Teoh, E.R., & Strouse, L.M. (2011). Overview of motorcycling in the United States: A national telephone survey. *Journal of Safety Research, 42*(3), 177-184.

Montarini, R., Borin, A., & Spadoni, A. (2011) SAFERIDER: results from Yamaha test site on advanced rider assistance system. In: *Proceedings of the 9th ACM SIGCHI Italian Chapter International Conference on Computer-Human Interaction: Facing Complexity* (pp. 132-138).

Motorcycle Safety Foundation. (2000). *National agenda for motorcycle safety* (DOT HS 809 156). Washington, DC: US Department of Transportation.

NHTSA (National Highway Traffic Safety Administration). (2009). *Traffic safety facts 2008 data - motorcycles* (DOT HS 811 157). Washington, DC: US Department of Transportation.

Nielsen, J. (1993). *Usability Engineering*. San Diego, CA: Academic Press, Inc.

Nordqvist, M., & Gregersen, N.P. (2011). *Study on motorcyclist's behavior and attitude towards road safety 2010*. Borlänge, Sweden: SMC.

Pauzié, A., & Guillot, L. (2008, July). Benchmarking Database (SafeRider Deliverable No. 1.1). Thessaloniki, Greece: SAFERIDER.

Regan, M., Triggs, T., Young, K., Tomasevic, N., Mitsopoulos, E., Stephan, K., & Tingvall, C. (2006). *On-road evaluation of intelligent speed adaptation, following distance warning and seat belt reminder systems: Final Results of the Australian TAC Safecar Project* (Report No. 253). Melbourne, Australia: Monash University Accident Research Centre.

Rizzi, M., Strandroth, J., & Tingvall, C. (2009). The effectiveness of antilock brake systems on motorcycles in reducing real-life crashes and injuries. *Traffic Injury Prevention, 10*(5), 479-487.

Schade, J., & Schlag, B. (2003). Acceptability of urban transport pricing strategies. *Transportation Research Part F: Traffic Psychology and Behaviour, 6*, 45-61.

Schlag, B., & Teubel, U. (1997). Public acceptability of transport pricing. *IATTS Research, 21*(2) 134-142.

Shladover, S.E. (1995). Review of the state of development of advanced vehicle control systems (AVCS). *Vehicle System Dynamics, 24*(6-7), 551-595.

Simpkin, B., Lai, F., Chorlton, K., & Fowkes, M. (2007). *ISA-UK, Intelligent Speed Adaptation. Results of motorcycle trial*. Leeds, UK: University of Leeds.

Teoh, E.R. (2011) Effectiveness of antilock braking systems in reducing motorcycle fatal crash rates. *Traffic Injury Prevention, 12*(2), 169-173.

Toyofuku, Y., Matsushima, K., Irie, Y., Yonezawa, H., & Mizuno, K. (1994). Study on the effects of motorcycle anti-lock-braking-system for skilled and less skilled riders: regarding braking in a turn. *JSAE Review, 15*(3), 223-228.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science, 41*, 427-443.

Vaa, T., Penttinen, M., & Spyropoulou, I. (2007). Intelligent transport systems and effects on road traffic accidents: State of the art. *IET Intelligent Transport Systems, 1*(2) 81-88.

van der Laan, J., Adriaan, H., & de Waard, D. (1997). A simple procedure for the assessment of acceptance of advanced transport telematics. *Transportation Research Part C: Emerging Technologies, 5*(1), 1-10.

Vlassenroot, S., Brookhuis, K, Marchau, V., & Witlox, F. (2010). 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). *Transportation Research Part F: Traffic Psychology and Behaviour, 13*(3), 164-178.

Walker, G.H, Stanton, N.A., & Salmon, P.M. (2011). Cognitive compatibility of motorcyclists and car drivers. *Accident Analysis and Prevention. 43*(3), 878-888.

WHO (World Health Organisation). (2004). *World Report on Road Traffic Injury Prevention*. Geneva, Switzerland: WHO.

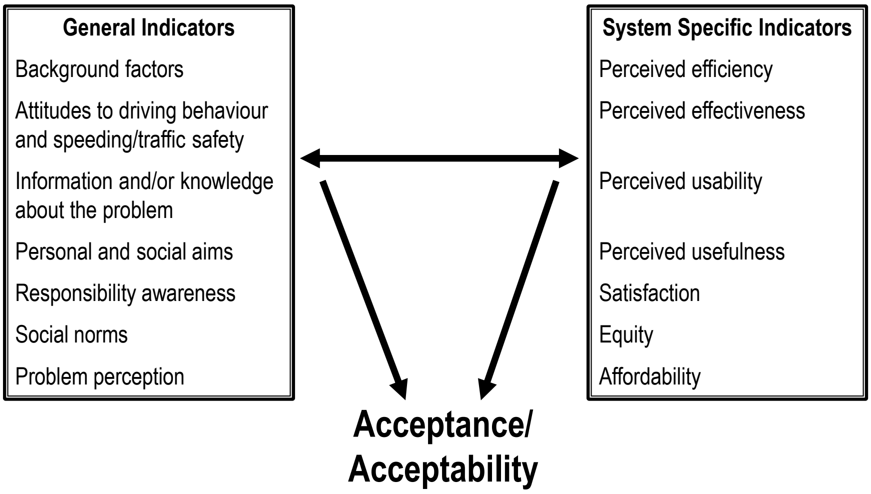

Figure 1. Vlassenroot et al.'s (2010) model of acceptability, differentiating between general indicators and system-specific indicators of acceptability.

Table 1
Overview of PTW assistive systems included in the current study

System	**Description of functionality**
Adaptive cruise control	Assistive system; adapts the distance to the vehicle ahead automatically
Advanced front-lighting system	Continuously adapts headlamp illumination according to the riding situation and ambient light
Airbag	Autonomous post-crash system; vehicle-mounted airbag is deployed in the event of a crash
Anti-lock braking system (ABS)	Autonomous braking system; prevents the wheels from locking when braking, especially on wet or slippery road surface
Blind spot monitor	Warning system; detects other vehicles located to the rider's side and rear
Collision warning system	Warning system; warns the rider of any dangers that may lie ahead on the road
Combined braking systems	Autonomous braking system; application of one brake control will activate both front and rear brakes, e.g. using automatic brake force distribution
Curve speed warning system	Warning system; Warns the rider if s/he enters a curve at a speed that is too fast to negotiate the curve safely
Emergency brake assistance	Autonomous braking system; Ensures maximum braking power in an emergency situation
Emergency call system (eCall) or Automatic crash notification	Autonomous post-crash system; sends vehicle information (e.g., GPS coordinates) to local emergency services in the event of a crash, in order to bring rapid assistance to riders
GPS navigation	Informative system
Intelligent speed adaptation	Assistive system; Monitors vehicle speed and local speed limit and either warns the rider (advisory ISA) or reduces speed (limiting ISA) when the vehicle is detected to be exceeding the speed limit
Lane keeping assistant	Assistive system; monitors vehicle lane position and warns the rider when the vehicle begins to move out of its lane
Night vision	Informative system; Vision enhancement systems provide an augmented view of the road environment and may employ radar, laser or infrared imaging to detect objects on the road
Slipper clutch/back-torque limiter	Autonomous system; Specialized clutch to mitigate the effects of engine braking when riders decelerate as they enter corners
Traction control system	Autonomous system; Intervenes and prevents the vehicle from sliding on loose or slippery surfaces
Tyre pressure control system	Warning system; Displays the air pressure and/or temperature measured in the tyres
Vacuum servo	Autonomous braking system; Provides assistance to the rider by decreasing the braking effort

Table 2

Survey respondents' demographic information by country

Country	Proportion of sample		Age in years		Gender	
	n	Percentage	*M*	*SD*	Males	Females
Australia	257	4.08%	52.4	10.4	85.6%	14.4%
Austria	32	0.51%	52.5	11.3	96.9%	3.1%
Czech Republic	3	0.05%	35.0	3.6	66.7%	33.3%
Finland	212	3.37%	37.6	11.4	93.9%	6.1%
France	1578	25.06%	42.0	11.6	94.1%	5.9%
Greece	456	7.24%	33.9	8.6	98.7%	1.3%
Germany	203	3.22%	43.9	11.2	83.7%	15.8%
Portugal	499	7.92%	36.0	9.3	96.2%	3.8%
Spain	7	0.11%	45.0	14.6	100.0%	0.0%
United Kingdom	2290	36.37%	46.8	11.2	92.2%	7.3%
Other[1]	743	11.80%	41.4	12.1	95.3%	4.6%
Total	6297		43.0	12.0	93.2%	6.4%

Note. Not all respondents provided full demographic information, so values do not total 100%.

[1] Other refers to respondents from countries other than Australia, Austria, Czech Republic, Finland, France, Greece, Germany, Portugal, Spain and the United Kingdom, as well as those respondents who did not nominate a country.

Table 3
Acceptability indices by cluster

System	Low acceptability	Moderate acceptability
	n = 2291 (37.6%)	*n* = 3801 (62.4%)
Braking enhancing systems	1.91	3.58
Traction control	1.76	3.37
Distance keeping	1.33	2.13
Navigation	2.25	3.28

Note. 1 = low acceptability, 5 = high acceptability.

Table 4

Acceptability means (and standard deviations) for each assistive system, overall and by acceptability cluster

System	Overall	Acceptability cluster		Significance***	Effect size (*r*)
		Low	Moderate		
Night vision	3.83 (1.36)	3.03 (1.55)	4.28 (0.99)	*t*(2977.1) = -32.69	**.51**
Anti-lock braking system	3.63 (1.49)	2.38 (1.38)	4.38 (0.95)	*t*(3516.4) = -60.54	**.71**
Advanced front-lighting system	3.61 (1.42)	2.78 (1.52)	4.10 (1.09)	*t*(3316.1) = -34.82	**.52**
eCall	3.42 (1.47)	2.64 (1.49)	3.89 (1.24)	*t*(3825.9) = -32.81	.47
Tyre pressure control system	3.21 (1.48)	2.44 (1.45)	3.67 (1.29)	*t*(4281.0) = -33.10	.45
Emergency brake assistance	3.15 (1.56)	1.94 (1.24)	3.86 (1.26)	*t*(4535.1) = -56.34	**.64**
Traction control system	3.11 (1.50)	1.84 (1.10)	3.87 (1.16)	*t*(4827.3) = -67.48	**.70**
Combined braking systems	3.09 (1.55)	1.96 (1.24)	3.76 (1.31)	*t*(4840.0) = -52.98	**.61**
GPS navigation	3.01 (1.42)	2.26 (1.31)	3.48 (1.27)	*t*(4656.8) = -35.68	.46
Blind spot monitor	2.87 (1.56)	1.98 (1.33)	3.40 (1.44)	*t*(4838.2) = -38.21	.48
Slipper clutch	2.71 (1.46)	1.90 (1.24)	3.21 (1.36)	*t*(4817.0) = -36.79	.47
Vacuum servo	2.67 (1.49)	1.83 (1.19)	3.16 (1.43)	*t*(5097.8) = -37.67	.47
Airbag	2.59 (1.51)	1.66 (1.13)	3.15 (1.42)	*t*(5423.2) = -44.06	**.51**
Collision warning system	2.51 (1.46)	1.62 (1.07)	3.05 (1.40)	*t*(5388.4) = -43.29	**.51**
Curve speed warning system	2.31 (1.39)	1.42 (0.85)	2.85 (1.37)	*t*(5582.8) = -47.77	**.54**
Intelligent speed adaptation	1.77 (1.18)	1.19 (0.61)	2.11 (1.30)	*t*(5537.3) = -36.28	.44
Lane keeping assistant	1.74 (1.16)	1.21 (2.07)	2.07 (1.27)	*t*(3203.8) = -17.65	.30
Adaptive cruise control	1.64 (1.07)	1.11 (0.45)	1.96 (1.20)	*t*(5054.0) = -38.26	.47

Note. 1 = low acceptability, 5 = high acceptability. Bolded figures indicate large effect sizes ($r \geq .5$). $^{***}p < .0005$ for all comparisons.

Table 5

Means (and standard deviations) for MOPROQ-2 items with differences between acceptability clusters

Item	Acceptability cluster		Significance***	Effect size
	Low	Moderate		(*r*)
		Personality traits		
Worry about things	2.05 (1.12)	2.74 (1.27)	*t*(5048.7) = -21.74	.29
Get upset easily	1.63 (0.90)	2.18 (1.09)	*t*(5348.5) = -21.09	.28
Fear for the worst	2.01 (1.20)	2.64 (1.29)	*t*(4828.2) = -18.95	.26
Get irritated easily	1.79 (1.01)	2.32 (1.14)	*t*(5088.5) = -18.57	.25
Get angry easily	1.61 (0.88)	2.09 (1.08)	*t*(5356.) = -18.61	.25
Love excitement	3.00 (1.18)	3.24 (1.15)	*t*(4510.9) = -7.77	.12
		Risky riding attitudes		
Riding is more than transportation; it is also speeding and fun	2.19 (1.41)	3.19 (1.40)	*t*(4299.3) = -26.00	.37
Exceed the speed limit on rural roads (more than 10 km/h)	2.51 (1.44)	3.34 (1.31)	*t*(4232.8) = -22.09	.32
Overtake the car in front when it is driving at the speed limit	2.37 (1.39)	3.17 (1.30)	*t*(4340.7) = -22.13	.32
I have a need for fun and excitement in traffic	1.69 (1.07)	2.39 (1.33)	*t*(5347.6) = -22.11	.29
There are many traffic rules which cannot be obeyed in order to keep up the traffic flow	2.49 (1.44)	3.20 (1.36)	*t*(4307.0) = -18.69	.27
If you are a safe rider, it is acceptable to exceed the speed limit by 10 km/h	2.39 (1.47)	3.12 (1.44)	*t*(4348.8) = -18.46	.27
Sometimes it is necessary to bend the traffic rules to arrive in time	1.91 (1.21)	2.54 (1.29)	*t*(4804.7) = -18.79	.26
Riding 5 or 10 miles above the speed limit is OK because everyone does it	2.28 (1.35)	2.90 (1.38)	*t*(4545.2) = -16.60	.24
If you are a safe rider, it is acceptable to exceed the speed limit by 20 km/h	2.04 (1.37)	2.62 (1.45)	*t*(4623.8) = -15.24	.22
It is OK to get round laws and rules as long as you do not break them directly	2.43 (1.39)	2.94 (1.29)	*t*(4107.9) = -13.74	.21
Ride fast to show others that I am tough enough	1.17 (0.49)	1.37 (0.67)	*t*(5749.9) = -13.31	.17
If something works, it is less important whether it is right or wrong	2.09 (1.22)	2.43 (1.19)	*t*(4341.4) = -10.38	.16
Ride the wrong way down a one-way street	1.04 (0.24)	1.14 (0.46)	*t*(5913.4) = -12.12	.16
Ride fast to show others I can handle the motorbike	1.23 (0.62)	1.44 (0.77)	*t*(5468.1) = -11.48	.15
Break traffic rules because they are too complicated to follow	1.30 (0.70)	1.51 (0.83)	*t*(5319.3) = -10.60	.14
Ride fast because the opposite sex enjoys it	1.11 (0.41)	1.24 (0.58)	*t*(5790.3) = -9.79	.13
It is all right to do anything you want as long as you keep out of trouble	1.83 (1.17)	2.07 (1.17)	*t*(4529.8) = -7.59	.11
Disregard red light on an empty road	1.12 (0.48)	1.22 (0.60)	*t*(5497.1) = -7.54	.10

Note. 1 = never, 5 = very often. ***$p < .0005$ for all comparisons.

Table 6

Acceptability means (and standard deviations) for each assistive system by country

System	Australia		Austria		Czech Republic		Finland		France		Greece		Germany		Portugal		Spain		UK	
	M (SD)	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank	*M (SD)*	rank
Night vision	**4.32 (0.91)**	**1**	3.87 (1.12)	7	**2.67 (2.08)**	**2**	**3.52 (1.18)**	**3**	**4.45 (0.91)**	**1**	**4.74 (0.61)**	**1**	2.98 (1.44)	11	**4.61 (0.73)**	**1**	**4.00 (1.55)**	**2**	**3.06 (1.49)**	**1**
Anti-lock braking system	**4.09 (1.25)**	**2**	**4.59 (0.98)**	**1**	**2.33 (1.53)**	**3**	**3.82 (1.31)**	**1**	**4.14 (1.17)**	**3**	**4.57 (0.84)**	**2**	**4.13 (1.18)**	**1**	**4.52 (0.90)**	**2**	**4.29 (1.50)**	**1**	2.67 (1.49)	4
Advanced front-lighting system	**4.02 (1.12)**	**3**	**4.31 (0.97)**	**2**	**3.67 (1.15)**	**1**	3.41 (1.23)	4	**4.18 (1.09)**	**2**	**4.55 (0.82)**	**3**	3.27 (1.46)	5	**4.51 (0.82)**	**3**	3.67 (1.51)	7	**2.85 (1.49)**	**2**
eCall	3.67 (1.31)	6	**4.19 (1.06)**	**3**	1.67 (1.15)	7	**3.62 (1.27)**	**2**	3.80 (1.32)	4	4.36 (1.10)	4	**3.53 (1.37)**	**2**	4.37 (0.99)	4	**4.00 (1.67)**	**3**	**2.74 (1.46)**	**3**
Tyre pressure control system	3.46 (1.36)	7	4.13 (1.16)	4	1.67 (1.15)	8	3.03 (1.29)	8	3.56 (1.38)	8	4.26 (1.07)	5	3.04 (1.46)	9	4.07 (1.19)	8	3.00 (1.90)	12	2.55 (1.43)	6
Emergency brake assistance	3.76 (1.32)	4	3.69 (1.47)	11	2.00 (1.73)	5	2.93 (1.42)	11	3.77 (1.35)	5	4.13 (1.20)	8	3.17 (1.45)	8	4.14 (1.13)	7	3.71 (1.89)	6	2.14 (1.34)	9
Traction control system	3.75 (1.33)	5	3.97 (1.09)	6	1.67 (1.15)	10	3.22 (1.33)	6	3.66 (1.32)	7	4.22 (1.06)	6	3.03 (1.38)	10	4.21 (1.03)	5	3.80 (1.79)	4	2.16 (1.31)	7
Combined braking system	3.35 (1.47)	9	3.71 (1.60)	10	2.00 (1.73)	4	2.94 (1.38)	10	3.76 (1.32)	6	4.13 (1.16)	7	**3.48 (1.41)**	**3**	4.20 (1.16)	6	3.71 (1.70)	5	2.08 (1.29)	11
GPS navigation	3.40 (1.40)	8	4.03 (1.38)	5	1.67 (1.15)	9	3.24 (1.29)	5	3.06 (1.38)	11	3.52 (1.24)	12	3.21 (1.40)	6	3.48 (1.30)	14	3.43 (1.99)	8	2.60 (1.41)	5
Blind spot monitor	3.32 (1.51)	10	3.81 (1.47)	8	1.67 (1.15)	11	2.95 (1.42)	9	3.33 (1.51)	10	3.62 (1.41)	11	3.30 (1.53)	4	3.89 (1.29)	9	3.33 (1.97)	10	2.14 (1.38)	8
Slipper clutch	3.26 (1.39)	11	3.44 (1.50)	14	1.00 (0.00)	15	3.11 (1.34)	7	2.75 (1.44)	13	3.85 (1.22)	9	2.93 (1.43)	12	3.51 (1.34)	13	2.40 (1.52)	15	2.11 (1.31)	10
Vacuum servo	2.77 (1.47)	14	3.16 (1.74)	15	2.00 (1.73)	6	2.60 (1.37)	14	2.94 (1.41)	12	3.52 (1.40)	13	3.19 (1.52)	7	3.78 (1.32)	10	3.29 (1.89)	11	1.99 (1.29)	12
Airbag	2.33 (1.35)	15	3.75 (1.37)	9	1.67 (1.15)	12	2.16 (1.21)	15	3.50 (1.32)	9	3.69 (1.34)	10	2.71 (1.53)	15	3.66 (1.26)	11	2.83 (2.04)	13	1.62 (1.05)	14
Collision warning system	3.18 (1.51)	12	3.55 (1.29)	12	1.33 (0.58)	14	2.89 (1.37)	12	2.67 (1.41)	14	3.19 (1.48)	15	2.81 (1.52)	13	3.59 (1.36)	12	2.83 (2.04)	14	1.85 (1.21)	13
Curve speed warning system	2.80 (1.50)	13	3.46 (1.35)	13	1.67 (1.15)	13	2.61 (1.27)	13	2.51 (1.37)	15	3.21 (1.37)	14	2.81 (1.51)	14	3.33 (1.33)	15	3.43 (1.99)	9	1.58 (1.01)	15
Intelligent speed adaptation	**2.30 (1.44)**	**17**	**2.53 (1.50)**	**16**	**1.00 (0.00)**	**16**	**1.80 (1.05)**	**17**	**1.86 (1.21)**	**17**	**1.94 (1.25)**	**18**	**1.85 (1.15)**	**16**	**2.69 (1.39)**	**16**	**1.83 (1.33)**	**16**	**1.38 (0.86)**	**16**
Lane keeping assistant	**2.32 (1.40)**	**16**	**1.97 (1.33)**	**18**	**1.00 (0.00)**	**18**	**1.82 (1.05)**	**16**	**2.01 (1.28)**	**16**	**2.12 (1.26)**	**16**	**1.67 (1.08)**	**18**	**2.62 (1.36)**	**17**	**1.83 (1.33)**	**17**	**1.27 (0.73)**	**17**
Adaptive cruise control	**2.09 (1.32)**	**18**	**2.23 (1.45)**	**17**	**1.00 (0.00)**	**17**	**1.75 (1.03)**	**18**	**1.70 (1.10)**	**18**	**2.12 (1.20)**	**17**	**1.75 (1.09)**	**17**	**2.44 (1.34)**	**18**	**1.67 (1.21)**	**18**	**1.24 (0.67)**	**18**

Note. Bolded figures indicate systems that were ranked as the three most acceptable or least acceptable systems within each country.