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TOPIC: Surface Transportation Systems

A Contribution to Situation Awareness Analysis: Understanding how mismatched expectations affect road safety

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Objective: The aim of the study was to clarify how knowledge elaborated by specific experience may lead to erroneous expectations during interactions between drivers and riders.

Background: *Situation Awareness* is partly determined by prior knowledge. Unshared knowledge may cause difficulties in managing driving interactions, but there is still an important gap in the literature devoted to this field of research.

Method: 226 participants were distinguished according to their use (type of vehicle driven, exclusive or dual drivers; and for the riders, the type of power two-wheeler used and its engine size) and their driving experience. Focusing on the most vulnerable users, prior representations to interactions were studied using a series of closed questions on drivers' performances relating to different stages of the interaction process from both the perspective of drivers' self-reflection and of riders' expectations.

Results: While most drivers are self-confident, their abilities tend to be questioned by riders. Owners of medium or large motorbike feel that drivers do not assess their approach speed accurately. Similarly, scooter riders doubt their ability to assess the distance that separates them from PTWs. Riders who use medium or large motorbikes are more likely to question drivers' skills in relation to crossing situations. Scooter riders do so more often for overtaking situations.

Conclusion: The development of shared prior knowledge is essential to prevent accidents and incidents between drivers and riders.

Application: To help improve effectiveness, we recommend specific ways of embedding each type of road user profile in training, prevention and research.

Key words: interaction, representation, exclusive/dual driving, attributed performance, motorcyclists, scooter riders, drivers.

INTRODUCTION

Motorcycles still account for less than 5% of all traffic in France, and yet motorcyclists account for 19.56 % of the drivers involved in injury accidents and 20.8 % of persons killed (ONISR, 2009). The share of riders in traffic is nonetheless constantly rising, especially in large metropolitan areas.

Is it because powered two-wheelers (PTWs) introduce in terms of size, performance and driving differential into the traffic system that the rider/driver interaction presents recurrent difficulties? In 2007, more than 65 % of all motorcycle accidents involved an interaction with a driver (ONISR, 2007). While 60% of fatal accidents occur outside urban areas, motorcycle accidents are predominantly concentrated in those areas. The most common accidents are: turns across the flow of traffic by the car (32.9% of accidents), right-of-way conflicts and a rigid attachment to right-of-way status by

motorcyclists who overestimate their being seen (29%), a motorcycle hitting a car from behind (10.1%), frontal collisions (overtaking or swerving: 14.7%) and dangerous vehicle manoeuvres (6.6% - of which 5.7% are due to a dangerous manoeuvre by the car, e.g. U-turns, driving against the traffic flow) (ONISR 2005).

Failures in managing interactions appear at different stages of the process and at different levels of cognition. They may result from different capacities of perception or action or from unshared knowledge, which can lead to erroneous or ill-suited beliefs. To try and address these issues, this paper begins by identifying some of the major constituting elements of prior knowledge – both of the *self* with regard to drivers' own abilities and that of the *other* with regard to riders' expectations. We then envisage the extent to which these may inform how different road users interact and anticipate other users' behaviour. We do not rely on an accidentological methodology but focus on the cognitive context formed prior to the interaction.

THEORY

The risks faced by riders when interacting with drivers

The weak conspicuity of PTWs is considered to be one of the major accident-causing factors. Using a sample of nearly 1,000 motorcycle accidents, Hurt and al. (1981) found weak or completely imperceptible PTW conspicuity to be a causal factor in 46% of cases against just 5.2% for the vehicles that collide with PTWs. These results were confirmed by Van Elslande and Fouquet (2003). On the basis of a qualitative study of prototypical scenarios of 80 accident cases involving a rider and a driver, they pointed out that more than 61% of these accidents are in part due to a problem in detecting this smaller vehicle, which is sometimes partially or totally hidden from the other user's field of vision. Additionally, the size of the PTW affects the driver's perception (Williams and Hoffmann, 1979; Wulf and al., 1989) and more specifically his/her perception of the motorcycle's distance/time ratio (Horswill and al., 2005). This size-arrival effect (DeLucia, 1991) affects judgements during left-hand turns (Caird and Hancock, 2002). A motorcycle's expected arrival time occurs significantly later than that of a four-wheel vehicle.

Furthermore, the prominence or prevalence of PTWs in overall traffic also affects their detectability. The probability and the distance of detection are strongly influenced by expectations. Several authors (Hancock and al., 1990; Herslund and Jørgensen, 2003; Maggazù and al., 2006; Clarke and al., 2007) suggest that motorcycles have weak cognitive conspicuity because they are less expected in traffic than cars. They therefore draw less attention from drivers, except for those drivers who also ride PTWs or have a friend or relative who rides a motorcycle. Riders believe that encountering a car is a potential risk factor, while drivers with experience of riding a PTW are more likely to see PTWs as a risk factor than those who do not have such experience. These are the results of a study based on open questions about the factors considered the "riskiest" among road users (Ragot-Court and al., submitted).

Riders do not always take their own weak detectability into account. The most inexperienced have behaviours that make them difficult to detect for drivers (Obenski, 1994). Weaving quickly between cars is a common behaviour among riders that makes them harder to detect (Van Elslande and Fouquet, 2003).

Generally speaking, motorcyclists choose higher speeds than drivers, overtake more frequently and merge into traffic at shorter inter-vehicle distances, and this despite the fact that they do not drive closer to the vehicle ahead of them (Horswill and Helman, 2003). There is no difference between motorcyclists' and drivers' behavioural intentions, such as sensation seeking (*ibid.*). Risky behaviours therefore are more often determined by the type of vehicle driven rather than individual characteristics and they only explain a small part of the excess risk related to riding a PTW. Furthermore, given motorcycles' acceleration capacity – on average twice that of cars – "risky" behaviours do not

necessarily lead to a proportional decrease in terms of safety margins (Van Elslande and al., 2008). Compared with other contributing factors (physical vulnerability, behaviour of other users, etc.), and taking into account demographic differences between motorcyclists and drivers, risky behaviours only have a small effect on the likelihood of motorcyclists experiencing an accident (Horswill and Helman, 2003). On the other hand, interaction with other road users, whatever the vehicle driven, is a major component of risk (Wilde, 1976).

The collective dimension of driving

Discussing the social dimension of automobile driving, Wilde (1976) stressed the high probability of conflicts occurring. Risser (1985) defines a conflict as “any observable event which would have led to an accident if one of the people involved had not slowed down, changed direction or accelerated to avoid a collision” (p.180). Next to the lawfulness and dangerousness of each type of behaviour, it is also important to consider users’ skills in managing interactions.

Analysis of verbal accounts given by drivers involved in roads accidents (Girard, 1996), lead us to distinguish four moments of the interaction which may lead a failure: 1/ *detecting* another user’s presence in the environment ; 2/ *characterizing the other user’s movement*, which includes the assessment of his/her speed and the inter-distance in order to determine if the other may interfere with their own objectives; 3/ *taking (or not) the other user into account*, or in other words getting ready to modify one’s behaviour to adapt it to their presence and manoeuvres; 4/ *anticipating* upcoming manoeuvres by the other user which means recognising his/her intention.

Risser (1985) makes a distinction between three driving behaviours: *standard behaviour* defined by a norm, *difficult behaviour* leading to a misunderstanding and *ideal behaviour* characterised by other users’ being taken into account, with the construction and development of knowledge making it possible to anticipate other users’ actions.

With regard to this latter foreseeing dimension, Mundutéguy and Darses (2007) show, through a study addressing the perception and the anticipation of other drivers’ behaviour in simulated car driving situation, that drivers infer other users’ intentions from the combination of *circumstantial data* and/or *permanent knowledge*. They argue that the interaction activates some elements of the permanent knowledge in the working memory while also helping to elaborate them. This permanent knowledge includes rules (formal or informal) as well as categories of affiliation such as the type of vehicle (scooter, medium or large motorcycle, etc.) and stereotypes which refer to prototypical behaviours associated with these vehicles (taxi, delivery van, courier, etc.). When prediction is difficult, participants often perform causal attribution whereby behavioural attitudes are expected to be determined by group prototype.

Knowledge prior to situation awareness: what is the level of sharing in the expectations?

Knowledge prior to interaction orients *situation awareness* (SA). According to Endsley (1995, p.36), “SA is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future”. In this normative sequential model, SA is the product of previous cognitive processes whose implementation corresponds to the “assessment of the situation”. SA is therefore a state of awareness, the result of the process of assessing the situation to predict future outcomes. At the same time, the driving situation is co-constructed during the interaction of both driver and vehicle with the infrastructure and other users. Through an interactionist approach, Smith and Hancock (1995) suggest that the environmental constraints for each agent require outward-looking, adaptive SA. They define SA as “the invariant in the agent-environment system that generates the momentary knowledge and behavior required to attain the goals specified by an arbiter of performance in the environment” (p.145). This SA generates both the behaviour needed to meet an external objective and “knowledge about and directed action within that environment” (p.138). Moreover, through actions, practice organises thought and, *a fortiori*, the representation of the surrounding world that each user interacts with. This practice which is determined by the type of vehicle(s) used may produce circumscribed knowledge among road users.

To determine more precisely each user's expectations in interactions, we must identify the knowledge that could underlie how they anticipate situations. In this paper, we refine this analysis by seeking to identify whether driving one particular type of vehicle leads to particular *prior representations* or expectations in relation to interactions. Respondents' expectations were collected outside situations. They are generic and their purpose is to show to what degree road users expect different perceptions of interactions in particular prototypical configurations. We consider that these expectations could guide users' perceptions of their interactions by leading their respective SA, notably in situations of uncertainty.

METHOD

Participants

226 male vehicle users participated in the study. They were questioned about their driving experience as riders (n=132) or drivers (n=94). Some of the respondents only use a PTW or a car – these are classed as “*exclusive*” – others use both a PTW and a car (58% of the whole sample) – these are classed as “*dual*”. Dual users were randomly asked to respond referring to only one of their two driving experiences, i.e. either as a rider or as a driver. Their *reference vehicle* was assigned accordingly in the questionnaire (Table 1).

For each group (exclusive or dual), only the driving experience with the reference vehicle was taken into account. One of the selection criteria was the prior experience of interactions having led to expectations about drivers' performances. Advanced beginners were thus given precedence over inexperienced users. The *less experienced* held between six months and two years of experience, while the *experienced* had at least five years with daily or nearly daily driving (with no less than 6 months per year). The average age of the riders was 32.2 years ($\sigma=9.15$) for the less experienced and 38.1 years ($\sigma=8.46$) for the experienced. The *less experienced* drivers were on average 27.4 years old ($\sigma=5.38$) compared to 43.8 ($\sigma=11.5$) for their *experienced* counterparts.

- Riders

Two additional criteria specific to PTWs were adopted: a distinction between *motorcyclists* (MOTO) and *scooter riders* (SCOOT), which doubles the number of exclusive riders with regard to the exclusive drivers, and the engine capacity of the PTW. For both types of PTW, this was defined as 125 cc for the *small* category (SM for motorcycles and SS for scooters). For the medium/large category (MLM for motorcycles and MLS for scooters), it was defined as ≥ 500 cc for motorcycles and ≥ 200 cc for scooters. Initially, the medium and large category was defined as ≥ 500 cc for both types of PTWs. The scarcity of scooters with ≥ 500 cc, even in the Paris region, however, led us to extend the *medium or large* scooter target to 200 cc and larger. Considering the wider range of engine capacity for motorcycles (up to 1,600 cc compared with a maximum of 850 cc for scooters), this extension only concerns scooters.

- Drivers

The sizes of the driver categories established using the initial selection criteria are presented in Table 1. So as not to skew the dual driver sample in relation to their use of the non-target vehicle, a homogenous distribution of motorcyclists and scooter riders, medium/large and small engine capacity for both types of PTWs was required at recruitment.

TABLE 1: Number of Drivers and Riders by vehicle, engine capacity, level or type of experience

Group	Engine Capacity	Level of Experience		Type of Experience		Total
		Less experienced [LE]	Experienced [Exp]	Dual [D]	Exclusive [Exc]	
Motorcycle [MOTO]	Small [SM]	16	16	16	16	32
	Medium or Large [MLM]	16	19	20	15	35
Scooter [SCOOT]	Small [SS]	19	18	19	18	37
	Medium or Large [MLS]	13	15	15	13	28
Automobile [AUTO]		31*	48	61**	33	94

* For 15 dual automobile drivers, it was unclear whether the responses given applied to the target or the non-target vehicle. We decided to exclude them from the experience variable.

** Of these 61 dual drivers, 30 ride a motorcycle, of which 14 small and 16 medium/large motorcycles and 31 ride a scooter, including 16 small and 15 medium/large scooters.

Material and Procedure

Participants were asked to provide personal, vehicle and driving related information with regard to two types of situations: *crossing situations* (intersections, roundabouts, right-of-way conflicts) and *overtaking situations* (rear-end collisions, left-hand turns). The items in the questionnaire relate to drivers' prior representations of the different stages in managing the interaction.

Two versions of the questionnaire were drawn up: one for the riders, and one for the drivers. Whichever the user's reference vehicle, the interaction was addressed focusing on the most vulnerable user: the rider (for more details see questionnaire in Appendix).

The interviews took place in the Paris region between September 2006 and the end of February 2007 and were conducted face-to-face at the participants' home or in any other location deemed suitable (office, etc.).

Analysis

The dependent measures are qualitative ordinals based on five-point Likert scales. Consequently, we used the non-parametric test of the ranks of Mann Whitney to determine the independence of the two samples. One of the samples to be compared being always above 20, the value of z which follows a normal pattern was postponed. The normal estimate is established in the following way: $z = (U - (n_1 * n_2) / 2) / \sqrt{((n_1 * n_2) * (n_1 + n_2 + 1)) / 12}$.

The dependent measures relate to participants' expectations of the level of: 1/ detection of riders by drivers, 2/ assessment of riders' speed by drivers, 3/ drivers' assessment of their distance with a rider, 4/ riders being taken into account by drivers; 5/ riders' manoeuvres being anticipated by drivers.

This procedure helps establish the *appraised level of performance* (of the self with regard to responses given by drivers and of the other with regard to responses given by riders). More precisely, we determine the level of concordance or discordance between the two main groups' and/or sub-groups' prior representations to interaction. Discordance may reflect some overrating or underrating of drivers' performances depending on viewpoints determined by experiences.

RESULTS

Distinctive expectations about drivers' abilities to detect riders

Whatever the situation discussed, while most riders and drivers consider that the latter often detect the former, drivers assess their frequency of detecting PTWs as being significantly higher than riders do.

Irrespective of the type of situation, the responses given by all riders differ significantly from drivers' own prior representations of their ability to detect a rider (PTW*AUTO: for Crossing Situations $p < .01$; for Overtaking Situations $p < .001$; MOTO: for CS $p < .01$ and for OS $p < .001$; SCOOTER: for CS $p < .01$ and for OS $p < .001$) (Table 2). The results are significant for all scooter riders, irrespective of engine capacity, driving experience or driving practice (SCOOTER*AUTO: $p < .001$; SS: $p < .001$; MLS: $p < .01$). Forty-three percent of the small scooter riders feel that drivers "sometimes" detect riders and 8.1% say they do so "rarely" or "very rarely". The percentages for medium or large scooter riders are respectively 22.9% and 17.1%. A considerable share of riders, whether they ride small or large motorcycles, also underrate the detection frequency of drivers' self-assessment (MOTO: $p < .001$; SM: $p < .05$; MLM: $p < .01$). Twenty-five percent of the riders with a small engine feel that drivers "sometimes" detect them (12.5% answer: "rarely"). They are respectively 28.6% and 14.1% among medium and large engine riders. Further results are available according to engine capacity, riders' level of experience and type of practice (Appendix, Table 3).

Turning to drivers' representations, experienced or dual drivers overestimate the detection of PTWs for crossing situations (AUTO*PTW: $p < .01$; AUTO_Exp: $p < .05$; AUTO_D: $p < .01$). This overrating effect is observed among all groups of drivers (AUTO*PTW: $p < .001$) for overtaking situations. Regarding crossing situations, 76.6% of the drivers sample think that they "often" or "very often" detect PTW while this is the case for 79.8% in relation to overtaking.

TABLE 2: U Mann-Whitney's test value (Z) comparing prior knowledge held by both categories of road users

Group	Stages in managing the interaction									
	Detection		Assessing the rider's approach speed		Assessing distance between vehicles		Taking the rider into account		Anticipation of the rider's manoeuvres	
	Crossing	Overtaking	Crossing	Overtaking	Crossing	Overtaking	Crossing	Overtaking	Crossing	Overtaking
PTW*	-2.82**	-4.98***	-1.71	-0.21	-3.69***	-4.47***	-6.81***	-7.68***	-6.84***	-5.66***
MOTO	-2.13*	-3.49***	-2.27*	-0.33	-3.79***	-3.25**	-5.57***	-6.07***	-6.07***	-4.15***
SM	-0.87	-2.11*	-0.5	-1.32	-2.74**	-2.66**	-3.67***	-4.21***	-2.99**	-2.65**
_LE	-1.53	-2.38*	-0.72	-1.34	-1.64	-2.17*	-2.93**	-3.71***	-2.20*	-1.49
_Exp	-0.21	-0.83	-1.49	-0.66	-2.54*	-1.92	-2.65**	-2.73**	-2.34*	-2.52*
_Exc	-2.00*	-1.66	-1.71	-0.47	-1.71	-1.15	-3.41**	-4.11***	-2.34*	-2.32*
_D	-0.70	-1.54	-0.95	-1.54	-2.46*	-2.95**	-2.16*	-2.32*	-2.20*	-1.69
MLM	-2.46*	-3.42**	-3.04**	-0.71	-3.33**	-2.61**	-5.18***	-5.49***	-6.58***	-3.93***
_LE	-1.98*	-2.30*	-2.04*	-0.70	-2.07*	-1.35	-3.95***	-4.00***	-4.99***	-4.02***
_Exp	-1.78	-2.87**	-2.60*	-0.40	-3.03**	-2.64**	-4.00***	-4.40***	-5.10***	-2.06*
_Exc	-1.42	-1.74	-2.46*	-0.52	-0.79	-0.25	-2.91**	-3.51***	-4.59***	-2.74**
_D	-2.25*	-3.32***	-2.22*	-1.44	-4.06***	-3.53***	-4.87***	-4.80***	-5.44***	-3.23**
SCOOT	-2.58*	-4.89***	-0.60	-0.01	-2.46*	-4.38***	-5.96***	-6.92***	-5.44***	-5.33***
SS	-2.47*	-4.26***	-0.25	-0.06	-2.18*	-4.18***	-4.54***	-6.19***	-5.44***	-4.84***
_LE	-1.97*	-4.06***	0	-0.35	-0.30	-2.88**	-4.31***	-5.51***	-4.28***	-4.46***
_Exp	-1.80	-2.43*	-0.39	-0.26	-3.12**	-3.60***	-2.66**	-4.01***	-4.05***	-2.92**
_Exc	-2.84**	-3.21**	-0.22	-0.81	-1.42	-2.84**	-4.54***	-5.07***	-4.32***	-3.72***
_D	-0.95	-3.31**	-0.16	-0.88	-1.93	-3.62***	-2.49*	-4.49***	-4.02***	-3.69***
MLS	-1.55	-3.41**	-1.35	-0.06	-1.74	-2.78**	-5.06***	-4.76***	-2.98**	-3.60***
_LE	-1.48	-2.10*	-0.05	-0.22	-1.77	-1.99*	-2.99**	-2.72**	-2.28*	-2.60**
_Exp	-0.87	-2.99**	-1.91	-0.29	-0.92	-2.25*	-4.61***	-4.45***	-2.19*	-2.80**
_Exc	-1.27	-1.99*	-0.99	-0.09	-0.29	-2.48*	-3.91***	-3.70***	-2.13*	-2.47*
_D	-1.07	-3.09**	-1.03	-0.01	-2.27*	-1.81	-3.77***	-3.53***	-2.33*	-2.93**
AUTO**	-2.82**	-4.98***	-1.71	-0.21	-3.69***	-4.47***	-6.81***	-7.68***	-6.84***	-5.66***
_LE	-1.62	-3.85***	-1.15	-0.51	-2.43*	-2.88**	-3.95***	-5.22***	-3.64***	-3.88***
_Exp	-2.05*	-3.46**	-1.16	-0.20	-2.79**	-3.56***	-5.67***	-5.65***	-5.72***	-4.11***
_Exc	-0.84	-3.76***	-1.79	-0.45	-2.20*	-3.06**	-4.57***	-5.71***	-3.90***	-3.52***
_D	-3.22**	-4.13***	-1.07	-0.58	-3.41**	-3.87***	-6.03***	-6.42***	-6.53***	-5.21***

Note: * $p < .05$; ** $p < .01$; *** $p < .001$ z in boldface.

* Rider sub-groups compared to the entire driver sample.

** Driver sub-groups compared to the entire rider sample.

Contrasted assessments of riders' flow through traffic

Owners of medium or large motorcycles are the sole group to display statistically significant differences on the assessment of riders' approach speeds by drivers in crossing situations.

When asked to discuss crossing situations, although no significant difference is observed between scooter riders and drivers, a clear majority of motorcyclists, and notably those who ride medium or large motorcycles, appears (MOTO*AUTO: $p < .05$; MLM: $p < .01$). Irrespective of driving experience or driving practice, 62.9% of riders feel that drivers underestimate their approach speed (Appendix, Table 4).

None of the drivers' representations differs statistically from those of riders irrespective of the type of interaction. Nearly half of the drivers sample (47.9% for CS and 48.9% for OS) believe that they "correctly" assess the speed of PTWs.

There is a marked divergence in appreciations between automobile drivers and riders regarding how drivers gauge inter-vehicle distances (PTW*AUTO: for CS $p < .001$ and for OS $p < .001$). Most drivers feel that, as a rule, they "correctly" assess it, whereas riders believe that drivers overestimate it, whatever the type of interaction.

If motorcyclists and scooter riders express similar views about drivers' assessment of inter-vehicle distance (MOTO: for CS $p < .001$ and for OS $p < .01$; SCOOTER: for CS $p < .05$ and for OS $p < .001$), the former stand out, whatever the engine size (SM: for CS and OS $p < .01$; MLM: for CS and OS $p < .01$) and for dual users (SM_D: for CS $p < .01$ and for OS $p < .001$; MLM_D: for CS and for OS $p < .001$) in all types of interactions. Once again, medium or large motorbike riders are more sceptical. Most think that drivers overestimate inter-vehicle distance (51.4% for CS and 48.6% for OS). This is the case for 65% of dual users and 57.9% of experienced users for crossing situations and 60% and 52.7% for overtaking situations.

By contrast, whatever the type of interaction, practice and/or level of experience, drivers tend to overestimate their ability to assess their distance with a rider, much more than riders think (AUTO*PTW: for CS and for OS $p < .001$). More specifically to dual drivers, most of them say their assessment is accurate (52.5% for CS and 57.4% for OS) whereas they tend to think that drivers overestimate inter-vehicle distance. Using a single type of vehicle or several types lead to different expectations about the skills held by others according the driving experience discussed.

Contrasted views on consideration and anticipation

Whatever the type of interaction, users' representations display statistically significant differences in all cases, except for small dual or less experienced motorcyclists in relation to overtaking situations (PTW*AUTO, CS: $p < .001$; OS: $p < .001$). When it comes to crossing situations, 48.5% of riders think that they are "often" or "very often" taken into account by drivers and 35.6% that it is only "sometimes" the case (Appendix, Table 6). With regard to overtaking situations, they are respectively 42.7% and 41.2%. The more sceptical are the dual medium or large PTW riders (for MLM_D and MLS_D, CS: $p < .001$; OS: $p < .001$). Thirty percent of the motorcyclists and 26.7% of the scooter riders believe that they are "rarely" taken into account by drivers in crossing situations. They are respectively 25% and 33.4% with regard to overtaking situations. By contrast, whatever the situation, drivers argue that they take riders into account much more than those tend to think (AUTO*PTW, CS: $p < .001$; OS: $p < .001$). A large majority (88.3%) feel that they "often" or "very often" take PTWs into account.

If riders generally believe they are being noticed, they are much more sceptical about drivers' readiness to adjust their manoeuvres. Indeed, we found divergences regarding the anticipation of manoeuvres (PTW*AUTO, CS: $p < .001$; OS: $p < .001$). The variables are statistically significant, except for overtaking situations involving dual or less experienced motorcyclists riding a small engine. However, there is no outright majority in the distribution of responses given by riders as to the frequencies (Appendix, Table 7). By contrast, drivers feel that they accurately anticipate riders' manoeuvres more often than these actually feel they do (AUTO*PTW, CS: $p < .001$; OS: $p < .001$). A

large majority feel that they “often” or “very often” anticipate riders’ manoeuvres (67% for CS and 68.1% for OS).

All these results are summarized in figures 1 and 2, showing the different stages of the interaction whereby 0 corresponds to the absence of divergence between the drivers’ expectations, taken at the central point of reference, and the six main categories of PTWR.

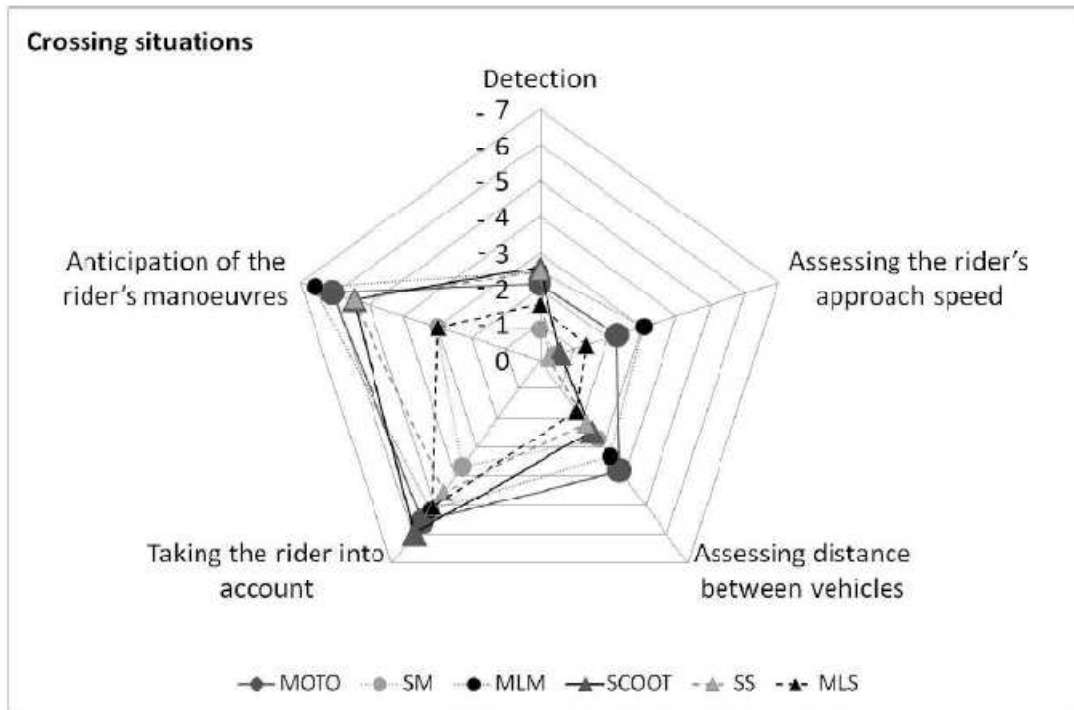


Figure 1. Spider chart with U Mann-Whitney's test value (Z) comparing prior knowledge held by drivers and the main categories of PTWR for crossing situations.

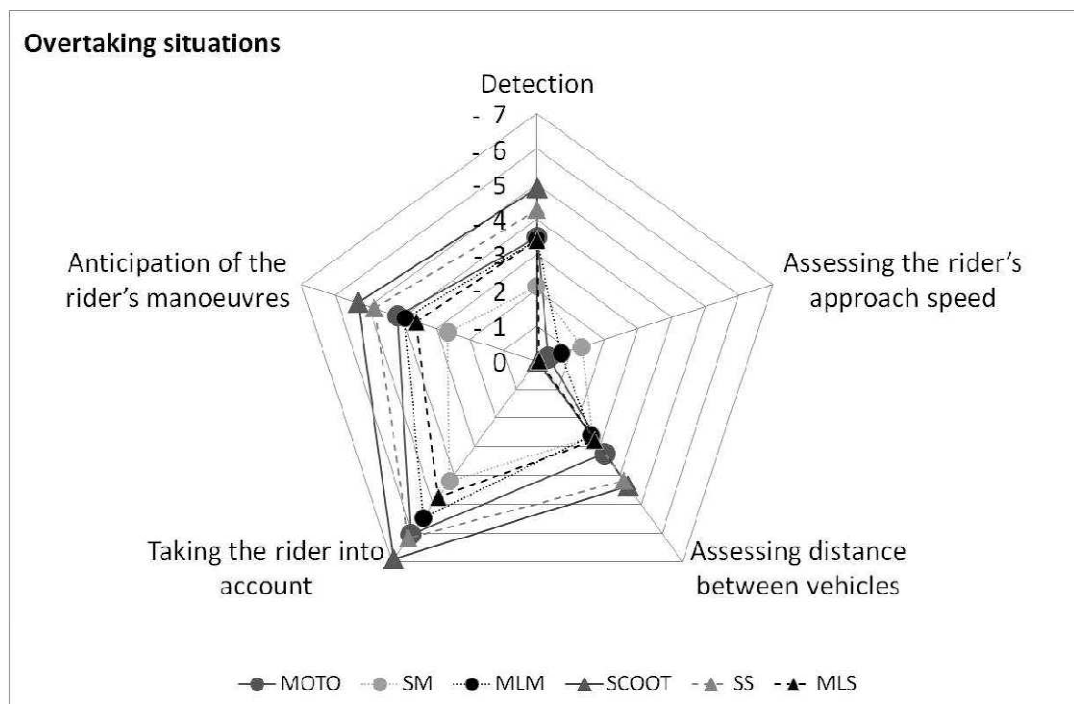


Figure 2. Spider chart with U Mann-Whitney's test value (Z) comparing prior knowledge held by drivers and the main categories of PTWR for overtaking situations.

DISCUSSION

Our findings show that drivers very rarely question their own driving. However, depending on the situation, the stage of interaction, and their level of experience, riders are more likely to criticise them.

Additionally, there is a relative consensus about drivers' assessment of riders' approach speed. Opinions are slightly contrasted when estimating detection and markedly different when inter-vehicle distance is mentioned. There are systematic divergences between the two categories of road users with regard to the likelihood of riders' actions being taken into account and anticipated by drivers. Even if these results can be refined and illustrated through specific experiences, they already underline several dimensions of unshared prior knowledge.

Weak cognitive and behavioural conspicuity make detection difficult

Riders of small bikes differ from other categories when discussing crossing situations. Riders of medium or large bikes stand out with regard to overtaking situations. The favourable size differential of the former enables riders to weave between vehicles which tends to make bikes hard to detect. Equally, because the latter have a larger engine, and thus a higher speed, medium or large motorcycles are just as likely to appear suddenly. This is in line with the notion of behavioural detectability discussed by several authors (Obenski, 1994, Van Elslande and al, 2008). The weak cognitive conspicuity of riders is thus reinforced by their weak behavioural conspicuity which relates to the use of the PTW.

Different levels of interaction lead to different levels of anticipation

Riders' prior representations of how their flow through traffic is assessed by drivers, lead us to draw a distinction between *distal* and *proximal interaction*. Distal interaction refers to what precedes the interaction. A road user's behaviour will lead other users to form expectations about whether this particular behaviour will interfere with their own objectives. They try to determine whether to take the other road user's manoeuvres in order to adjust their behaviour and avoid conflict. Interaction becomes proximal when drivers are close or in pre-contact phase. Distal interaction may only be relevant to the fastest riders (medium or large motorbikes). This is the only respondent group to question drivers' abilities to assess their speed approach accurately. Finally, riders' and drivers' views diverge strongly with regard to drivers' distance assessment, consideration for riders and ability to anticipate. These abilities are much more relevant to proximal interaction.

Prior knowledge informs Situation Awareness

Smith and Hancock (1995) have argued that SA gathers circumstantial data as well as knowledge designed for and led by action. Our results shed light on the extent to which experience shapes part of this knowledge and leads to different appraisals. Driving experience, together with the type of vehicle used, leads to expectations that strongly influence anticipation in situations of uncertainty (Mundutéguy and Darses, 2007). To reduce the consequences of unshared SA between road users, it is important to address these prior knowledge gaps or deficiencies and to reduce their influence on the assessment of the situation.

CONCLUSION

This article has shown that knowledge developed during practice generates expectations during interactions. Different practices can yield several types of knowledge and unshared situation awareness. Certain countries do not make it a legal requirement to hold a licence for certain categories of vehicles (e.g. scooter under 50 cc). However our results suggest that actions should be taken not only to broaden this requirement to all road users but also to raise mutual awareness of the constraints faced by other types of users. Such actions could consist of training sessions providing some experience of driving the other type of vehicle as well as feedbacks to the other categories of users. Each user could underline the constraints faced in general and more specifically during interactions. Taking the other users into

account and understanding their constraints could considerably reduce crash risks. More widely speaking, both in research, training and prevention, we must stop considering riders as a homogenous group.

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KEY POINTS

- Unshared Situation Awareness is not only the result of distinctive perceptions. It is also determined by prior knowledge stemming from specific practices developed *ex ante*.
- Different driving experiences lead to different expectations in situations of interaction.
- Prior knowledge held by riders, is determined by the type of PTW used (i.e. motorcyclists, scooter riders and the engine capacity).
- Whatever the stage of interaction discussed, drivers express more positive feelings about their own driving than those expressed by riders.
- The views held by riders regarding drivers' abilities to assess their flow through traffic are crucial to identify proximal and distal interactions.

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APPENDIX

QUESTIONNAIRE

Guidelines for participants: “We want to record your opinion about driving situations where drivers and riders move in the same road environment. We are interested in two specific situations: crossing situations and overtaking situations. By crossing situations, we mean: intersections, roundabouts, right-of-way conflicts”.

Specific guidelines for the drivers: “Overtaking situations concerns the situations where a rider is catching up with you and begins to overtake your car”.

Specific guidelines for the riders: “Overtaking situations concerns the situations in which you’re catching up with a car and begin to overtake it”.

	Drivers	Riders
Detection of riders by drivers		
(Scale used to rate the item: 1/very rarely; 2/ rarely; 3/ sometimes; 4/ often; 5/ very often.)		
DR1	In crossing situations (intersections, roundabouts, etc.), when they come from the right or from the left, do you as a driver think you spot riders?	In crossing situations (intersections, roundabouts, etc.), when you come from the right or from the left, as a rider do you think drivers spot you?
DR2	When a rider overtakes your car, do you think you spot him?	When you overtake an automobile, do you think driver spot you?
Perception of riders’ speed by drivers		
(Scale used to rate the item: 1/much faster than it is; 2/ a little faster than it is; 3/ accurate; 4/ a little slower than it is; 5/ much slower than it is)		
PS1	In crossing situations, do you as a driver perceive riders’ approach speed as being...?	In crossing situations, as a rider, do you think that drivers assess your approach speed as being...?
PS2	When a rider overtakes you, do you as a driver perceive his approach speed as being...?	When you overtake an automobile, as a rider, do you think that driver assess your approach speed as being...?
Perception of inter-distance between riders and drivers by these latter		
(Scale used to rate the item: 1/ much longer than it is; 2/ slightly longer than it is; 3/ in line with reality; 4/ slightly shorter than it is; 5/ much shorter than it is.)		
PD1	In crossing situations, do you as a driver think you gauge the distance between you and the rider as being...?	In crossing situations, as a rider, do you think that drivers gauge the distance between themselves and you as being...?
PD2	When a rider overtakes your car, do you, as an driver think you gauge the distance between you the rider as being...?	When you overtake an automobile, as a rider, do you think that driver gauges the distance between him and you as being....?
Consideration given by drivers		
(Scale used to rate the item: 1/ very rarely; 2/ rarely; 3/ sometimes; 4/ often; 5/ very often.)		
C1	By defining consideration as having at least the intention, when necessary, to modify one’s driving to adapt it to the other user’s driving,.. ... in crossing situations, do you as a driver think you take the riders into account?	... in crossing situations, as a rider, do you think that driver takes you into account?
C2	When a rider overtakes your car, do you, as a driver think you take him into account?	When you overtake an automobile, as a rider, do you think that driver takes you into account?
Anticipating upcoming riders’ manoeuvres by drivers		
(Scale used to rate the item: 1/ very rarely; 2/ rarely; 3/ sometimes; 4/ often; 5/ very often.)		
A1	In crossing situations, do you as a driver think you accurately anticipate the rider’s upcoming manoeuvre ...?	In crossing situations, as a rider, do you think that driver accurately anticipates your manoeuvre...?
A2	When a rider overtakes your car, do you, as a driver think you accurately anticipate the rider’s upcoming manoeuvre ...?	When you overtake an automobile, as a rider, do you think that driver accurately anticipates your manoeuvre...?

TABLE 3: Riders and drivers' assessment of drivers' detection

Group	Responses Distribution									
	Crossing situations					Overtaking situations				
	1	2	3	4	5	1	2	3	4	5
Riders	1.5	6.8	22.0	52.3	17.4	1.5	11.4	30.3	49.2	7.6
Motorcycle	3.0	6.0	17.9	55.2	17.9		14.9	23.9	49.3	11.9
Small motorcycle	3.1	3.1	15.6	53.1	25.0		12.5	25	43.8	18.8
Less experienced	6.3		12.5	75.0	6.3		18.8	18.8	56.3	6.3
Experienced		6.3	18.8	31.3	43.8		6.3	31.3	31.3	31.3
Exclusive	6.3	6.3	25.0	50.0	12.5		12.5	18.8	56.3	12.5
Dual			6.3	56.3	37.5		12.5	31.3	31.3	25.0
Medium or large motorcycle	2.9	8.6	20.0	57.1	11.4		17.1	22.9	54.3	5.7
Less experienced		6.3	25.0	62.5	6.3		12.5	25.0	56.3	6.3
Experienced	5.3	10.5	15.8	52.6	15.8		21.1	21.1	52.6	5.3
Exclusive	6.7		20.0	60.0	13.3		13.3	13.3	66.7	6.7
Dual		15.0	20.0	55.0	10.0		20.0	30.0	45.0	5.0
Scooter		7.7	26.2	49.2	16.9	3.1	7.7	36.9	49.2	3.1
Small scooter		8.1	27.0	51.4	13.5	2.7	5.4	43.2	45.9	2.7
Less experienced		10.5	21.1	57.9	10.5	5.3	5.3	52.6	36.8	
Experienced		5.6	33.3	44.4	16.7		5.6	33.3	55.6	5.6
Exclusive		5.6	44.4	44.4	5.6			50.0	50.0	
Dual		10.5	10.5	57.9	21.1	5.3	10.5	36.8	42.1	5.3
Medium or large scooter		7.1	25.0	46.4	21.4	3.6	10.7	28.6	53.6	3.6
Less experienced		15.4	15.4	53.8	15.4		15.4	23.1	53.8	7.7
Experienced			33.3	40.0	26.7	6.7	6.7	33.3	53.3	
Exclusive			30.8	53.8	15.4			30.8	69.2	
Dual		13.3	20.0	40.0	26.7	6.7	20.0	26.7	40.0	6.7
Drivers	1.1	4.3	18.1	38.3	38.3	1.1	1.1	18.1	48.9	30.9
Less experienced		3.2	25.8	32.3	38.7			16.1	51.5	32.3
Experienced	2.1	4.2	16.7	41.7	35.4	2.1	2.1	20.8	43.8	31.3
Exclusive	3.0	6.1	18.2	45.5	27.3	3.0		12.1	54.5	30.3
Dual		3.3	18.0	34.4	44.3		1.6	21.3	45.9	31.1

Response types: 1 - very rarely, 2 – rarely, 3 – Sometimes, 4 – Often, 5 – Very Often.

TABLE 4: *Riders and drivers' assessment of drivers' assessing approach speed by other*

Group	Responses Distribution									
	Crossing situations					Overtaking situations				
	1	2	3	4	5	1	2	3	4	5
Riders	6.1	18.2	31.8	31.1	12.9	8.3	25.8	29.5	26.5	9.8
Motorcycle	9.0	11.9	28.4	35.8	14.9	11.9	23.9	28.4	22.4	13.4
Small motorcycle	6.3	15.6	40.6	37.5		9.4	28.1	37.5	25.0	
Less experienced	12.5	25.0	31.3	31.3		12.5	31.3	31.3	25.0	
Experienced		6.3	50.0	43.8		6.3	25.0	43.8	25.0	
Exclusive	6.3		43.8	50.0		12.5	18.8	37.5	31.3	
Dual	6.3	31.3	37.5	25.0		6.3	37.5	37.5	18.8	
Medium or large motorcycle	11.4	8.6	17.1	34.3	28.6	14.3	20.0	20.0	25.7	
Less experienced	12.5	12.5	12.5	31.3	31.3	12.5	18.8	25.0	12.5	31.3
Experienced	10.5	5.3	21.1	36.8	26.3	15.8	21.1	15.8	26.3	21.1
Exclusive	13.3		20.0	46.7	20.0	13.3	26.7	26.7	20.0	13.3
Dual	10.0	15.0	15.0	25.0	35.0	15.0	15.0	15.0	20.0	35.0
Scooter	3.1	24.6	35.4	26.2	10.8	4.6	27.7	30.8	30.8	6.2
Small scooter	2.7	29.7	35.1	27.0	5.4	5.4	27.0	29.7	35.1	2.7
Less experienced		36.8	26.3	26.3	10.5	10.5	31.6	15.8	36.8	5.3
Experienced	5.6	22.2	44.4	27.8			22.5	44.4	33.3	
Exclusive	5.6	27.8	33.3	27.8	5.6		22.2	33.3	44.4	
Dual		31.6	36.8	26.3	5.3	10.5	31.6	26.3	26.3	5.3
Medium or large scooter	3.6	17.9	35.7	25.0	17.9	3.6	28.6	32.1	25.0	10.7
Less experienced		30.8	38.5	15.4	15.4	7.7	30.8	23.1	30.8	7.7
Experienced	6.7	6.7	33.3	33.3	20.0		26.7	40.0	20.0	13.3
Exclusive	7.7	7.7	38.5	46.2			30.8	30.8	38.5	
Dual		26.7	33.3	6.7	33.3	6.7	26.7	33.3	13.3	20.0
Drivers	6.4	16.0	47.9	27.7	2.1	4.3	19.1	48.9	20.2	7.4
Less experienced	3.2	9.7	64.5	22.6		3.2	12.9	58.1	16.1	9.7
Experienced	8.3	20.8	33.3	33.3	4.2	4.2	22.9	41.7	22.9	8.3
Exclusive	9.1	15.2	54.5	18.2	3.0	3.0	21.2	60.6	6.1	9.1
Dual	4.9	16.4	44.3	32.8	1.6	4.9	18.0	42.6	27.9	6.6

Response types: 1 – *much too fast*, 2 – *a little too fast*, 3 – *accurately*, 4 – *a little too slow*, 5 – *much too slow*.

TABLE 5: Riders and drivers' assessment of drivers' assessing distance between vehicles

Group	Responses Distribution									
	Crossing situations					Overtaking situations				
	1	2	3	4	5	1	2	3	4	5
Riders	6.8	34.8	39.4	12.9	6.1	4.5	40.9	34.1	12.9	7.6
Motorcycle	9.0	35.8	40.3	7.5	7.5	4.5	40.3	31.3	11.9	11.9
Small motorcycle		37.5	50.0	9.4	3.1	3.1	37.5	37.5	15.6	6.3
Less experienced		37.5	43.8	12.5	6.3	6.3	43.8	25.0	12.5	12.5
Experienced		37.5	56.3	6.3			31.3	50.0	18.8	
Exclusive		31.3	56.3	6.3	6.3		37.5	31.3	18.8	12.5
Dual		43.8	43.8	12.5		6.3	37.5	43.8	12.5	
Medium or large motorcycle	17.1	34.3	31.4	5.7	11.4	5.7	42.9	25.7	8.6	17.1
Less experienced	12.5	31.3	37.5	12.5	6.3	6.3	37.5	25.0	12.5	18.8
Experienced	21.1	36.8	26.3		15.8	5.3	47.4	26.3	5.3	15.8
Exclusive		33.3	40.0	13.3	13.3		33.3	26.7	20.0	20.0
Dual	30.0	35.0	25.0		10.0	10.0	50.0	25.0		15.0
Scooter	4.6	33.8	38.5	18.5	4.6	4.6	41.5	36.9	13.8	3.1
Small scooter	5.4	29.7	45.9	13.5	5.4	8.1	35.1	45.9	10.8	
Less experienced	5.3	21.1	42.1	21.1	10.5	10.5	31.6	42.1	15.8	
Experienced	5.6	38.9	50.0	5.6		5.6	38.9	50.0	5.6	
Exclusive	5.6	22.2	55.6	11.1	5.6	5.6	38.9	38.9	16.7	
Dual	5.3	36.8	36.8	15.8	5.3	10.5	31.6	52.6	5.3	
Medium or large scooter	3.6	39.3	28.6	25.0	3.6		50.0	25.0	17.9	7.1
Less experienced		46.2	30.8	23.1		46.2	30.8	15.4	7.7	
Experienced	6.7	33.3	26.7	26.7	6.7		53.3	20.0	20.0	6.7
Exclusive	7.7	23.1	30.8	38.5			53.8	23.1	23.1	
Dual		53.3	26.7	13.3	6.7		46.7	26.7	13.3	13.3
Drivers	1.1	12.8	58.5	25.5	2.1	2.1	6.4	61.7	24.5	5.3
Less experienced		9.7	71.0	16.1	3.2	3.2	3.2	67.7	22.6	3.2
Experienced	2.1	16.7	47.9	31.3	2.1	2.1	10.4	52.1	27.1	8.3
Exclusive		12.1	69.7	18.2			6.1	69.7	21.2	3.0
Dual	1.6	13.1	52.5	29.5	3.3	3.3	6.6	57.4	26.2	6.6

Response types: 1 – much too long, 2 – a little too long, 3 – correctly, 4 – a little too small, 5 – much too small.

TABLE 6: Riders and drivers' assessment of the level of consideration given by drivers

Group	Responses Distribution									
	Crossing situations					Overtaking situations				
	1	2	3	4	5	1	2	3	4	5
Riders	3.0	12.9	35.6	37.9	10.6	2.3	13.7	41.2	36.6	6.1
Motorcycle	4.5	13.4	26.9	46.3	9.0	1.5	14.9	35.8	40.3	7.5
Small motorcycle	3.1	9.4	25.0	50.0	12.5		12.5	37.5	37.5	12.5
Less experienced	6.3	6.3	18.8	62.5	6.3		25.0	25.0	43.8	6.3
Experienced		12.5	31.3	37.5	18.8			50.0	31.3	18.8
Exclusive		12.5	31.3	50.0	6.3		12.5	50.0	31.3	6.3
Dual	6.3	6.3	18.8	50.0	18.8		12.5	25.0	43.8	18.8
Medium or large motorcycle	5.7	17.1	28.6	42.9	5.7	2.9	17.1	34.3	42.9	2.9
Less experienced	6.3	12.5	37.5	37.5	6.3		12.5	37.5	50.0	
Experienced	5.3	21.1	21.1	47.4	5.3	5.3	21.1	31.6	36.8	5.3
Exclusive		13.3	20.0	60.0	6.7		13.3	26.7	60.0	
Dual	10.0	20.0	35.0	30.0	5.0	5.0	20.0	40.0	30.0	5.0
Scooter	1.5	12.3	44.6	29.2	12.3	3.1	12.5	46.9	32.8	4.7
Small scooter		10.8	45.9	27.0	16.2	2.7	5.4	59.5	29.7	2.7
Less experienced		15.8	57.9	10.5	15.8	5.3	5.3	68.4	21.1	
Experienced		5.6	33.3	44.4	16.7		5.6	50.0	38.9	5.6
Exclusive		11.1	55.6	27.8	5.6		5.6	66.7	27.8	
Dual		10.5	36.8	26.3	26.3	5.3	5.3	52.6	31.6	5.3
Medium or large scooter	3.6	14.3	42.9	32.1	7.1	3.7	22.2	29.6	37.0	7.4
Less experienced		15.4	38.5	30.8	15.4		23.1	23.1	38.5	15.4
Experienced	6.7	13.3	46.7	33.3		7.1	21.4	35.7	35.7	
Exclusive		7.7	61.5	23.1	7.7		16.7	50.0	25.0	8.3
Dual	6.7	20.0	26.7	40.0	6.7	6.7	26.7	13.3	46.7	6.7
Drivers	1.1		11.7	46.8	40.4		2.1	9.6	51.1	37.2
Less experienced	3.2		16.1	41.9	38.7		3.2	6.5	54.8	35.5
Experienced			10.4	50.0	39.6		2.1	14.6	47.9	35.4
Exclusive			15.2	45.5	39.4			6.1	60.6	33.3
Dual	1.6		9.8	47.5	41		3.3	11.5	45.9	39.3

Response types: 1 – very rarely, 2 – rarely, 3 – sometimes, 4 – often, 5 – very often.

TABLE 7: Riders and drivers' assessment of the level of anticipation of upcoming manoeuvres by the other user by drivers

Group	Responses Distribution									
	Crossing situations					Overtaking situations				
	1	2	3	4	5	1	2	3	4	5
Riders	9.8	23.5	37.1	28.0	1.5	8.3	18.2	36.4	34.1	3.0
Motorcycle	11.9	26.9	34.3	23.9	3.0	7.5	17.9	32.8	35.8	6.0
Small motorcycle		21.9	34.4	37.5	6.3	6.3	15.6	31.3	37.5	9.4
Less experienced		18.8	37.5	37.5	6.3	6.3	18.8	25.0	31.3	18.8
Experienced		25.0	31.3	37.5	6.3	6.3	12.5	37.5	43.8	
Exclusive		25.0	31.3	37.5	6.3		25.0	31.3	37.5	6.3
Dual		18.8	37.5	37.5	6.3	12.5	6.3	31.3	37.5	12.5
Medium or large motorcycle	22.9	31.4	34.3	11.4		8.6	20.0	34.3	34.3	2.9
Less experienced	25.0	37.5	25.0	12.5		12.5	25.0	43.8	18.8	
Experienced	21.1	26.3	42.1	10.5		5.3	15.8	26.3	47.4	5.3
Exclusive	13.3	40.0	33.3	13.3			26.7	33.3	40.0	
Dual	30.0	25.0	35.0	10.0		15.0	15.0	35.0	30.0	5.0
Scooter	7.7	20.0	40.0	32.3		9.2	18.5	40.0	32.3	
Small scooter	8.1	27.0	43.2	21.6		10.8	24.3	35.1	29.7	
Less experienced	15.8	31.6	26.3	26.3		21.1	26.3	31.6	21.1	
Experienced		22.2	61.1	16.7			22.2	38.9	38.9	
Exclusive	5.6	27.8	50.0	16.7		11.1	22.2	38.9	27.8	
Dual	10.5	26.3	36.8	26.3		10.5	26.3	31.6	31.6	
Medium or large scooter	7.1	10.7	35.7	46.4		7.1	10.7	46.4	35.7	
Less experienced	7.7	15.4	30.8	46.2		7.7	15.4	38.5	38.5	
Experienced	6.7	6.7	40.0	46.7		6.7	6.7	53.3	33.3	
Exclusive			61.5	38.5				69.2	30.8	
Dual	13.3	20.0	13.3	53.3		13.3	20.0	26.7	40.0	
Drivers		5.3	27.7	43.6	23.4	2.1	5.3	24.5	42.6	25.5
Less experienced		6.5	41.9	29	22.6	3.2	6.5	19.4	45.2	25.8
Experienced		6.3	22.9	45.8	25.0	2.1	6.3	29.2	35.4	27.1
Exclusive		9.1	33.3	36.4	21.2	3.0	9.1	21.2	42.4	24.2
Dual		3.3	24.6	47.5	24.6	1.6	3.3	26.2	42.6	26.2

Response types: 1 – very rarely, 2 – rarely, 3 – sometimes, 4 – often, 5 – very often.