STRONG FEELING OF RIGHT-OF-WAY AND REACTION TIME ANALYSIS OF ACCIDENTS IN INTERSECTIONS

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ABSTRACT

Reaction time is a characteristic of human behaviour that is of interest to researchers in the human sciences, notably accidentologists and road infrastructure engineers who need to adapt the layout and environment to drivers.
Detailed Accident Studies (EDAs – Études Détaillées des Accidents) can be used to perform in-depth analyses of accident mechanisms. Using a sample of cases of accidents in intersections taken from EDAs, we have characterised the behaviour typologies of drivers who have the right-of-way at the approach to intersections and in accident situations. It is then a question of understanding how the characteristics of the infrastructure and of drivers lead to the feeling of right-of-way at work in the accident.
Reaction time can be sharply increased in certain drivers due to a conscious or unconscious demand for priority. Fine analysis of accidents has shown that, in some cases, a factor related to a strong feeling of right-of-way, which increases reaction time, plays a role in producing accidents and their processes. In other words, drivers appear to waste the space-time available and necessary to reacting.
We are then able to define courses of action for improving behaviours (training, education, etc.) and infrastructures (sight distance, environment, signage, etc.).

1. INTRODUCTION

"Road construction is a field for engineers. Determining the needs of road users is a field for psychologists. It is necessary to bridge the gap between these two professions if we are to design roads that can be easily understood and that have the characteristics required to efficiently reduce driving errors and accidents. Road engineering standards should be based on the behaviour, capacities and limitations of human beings" [1].
This need has long been taken into account by the researchers of IFSTTAR (Accident Mechanisms Research Unit) which combines different engineering sciences with human and social sciences in the analysis of road safety and traffic system malfunctioning. Multidisciplinary analyses of accidents have therefore resulted in reflection on improving road and urban development [2][3][4].

Apart from classical factors characterising driver behaviour: stress and workload, perception, trajectory in lanes, choice of gear, orientation and anticipation, that have been studied in detail by many researchers, we focus here on driver reaction time

(RT) that incorporates a "conviction of having right of way". A driver subject to this strong conviction of having right of way neglects warning signals indicating a conflictual situation. By failing to exercise control (slowing down, observation), they participate in the genesis of an accident. Although well-known and highlighted in accident studies [5][6], this parameter has been given little attention. It is very difficult to measure and its estimation remains subjective.

A large number of studies have attempted to define a value for reaction time in experimental or ecological frameworks. Classically, RT is broken down into five phases: perception, identification, recalling in memory the response linked to the signal recognised previously, recall in memory the motor code for executing the response, and execution. There is a sixth phase related to the mechanical response of the vehicle. The duration of each phase depends on numerous factors linked to the individual (experience, fatigue, etc.) and the situation (traffic, weather, infrastructure, etc.).

In the framework of this study, we assume that a driver's reaction time, from the "identification" phase to the "recall in memory of the associated response" can be greatly increased in certain drivers, due to the conscious or unconscious conviction of having right of way. In other words, drivers waste available space and time when reacting, and a factor linked to the conviction of right of way can play a role in the occurrence and sequence of the accident.
Detailed accident studies (EDA) developed at the Accident Mechanisms Unit of IFSTTAR allow thorough analysis of the dysfunctions involved [7]. Indeed, drivers having had an accident can speak with a psychologist immediately after the event. During this interview, drivers are encouraged to express their perceptions, their intentions and reactions throughout the sequence of the accident, thereby permitting researchers to understand the mechanisms involved with precision [8].

Initially, a short passage on the references on reaction time is provided so that the reader can take into account the magnitudes usually accepted. This is followed by a description of the methodology used and the sample of accidents studied on the basis of EDA. The results are presented by family of accident on the basis of the characteristics of the driver's conviction of having right of way when approaching a road junction and in an accident situation. Orientations are therefore defined in terms of improving behaviour (training, education, etc.) and infrastructure (distance of visibility, environment, signalling, etc.). Perspectives are considered in terms of increasing knowledge of reaction time and layout configurations, by using a driving simulator that incorporates accident scenarios.

2. REACTION TIME

Measurement of RT in an experimental framework is acceptable "when an adequate response is given within the minimum time required to give it and when this response is triggered by the occurrence of a signal" [9]. RT is a sensitive measurement subject to many factors. It can be broken down into several steps that vary as a function of the individual and the experimental conditions. Thus it cannot be determined universally for all individuals and for all situations, since it involves complex perceptive, cognitive and motor mechanisms.

The Theios model breaks down the process activated between the perception of the stimulus and the production of the observable response into a series of phases [10]. This makes it possible to appreciate reaction time by using the internal representation of operations bringing perception, cognition and motoricity into play. RT depends on the duration of each phase and, among other things, applies to car driving.

This model of processing information proposes the following breakdown in the form of phases:
- 1. Perception of the signal, which corresponds to the information coding time taken by the receptive organs used. In a driving situation the signal can be visual or auditive.
- 2. Identification of the signal, which requires the cognitive activity of signal recognition. This is the phase in which the driver determines the problem confronting them (a vehicle blocking their route or the squeal of brakes).
- 3. Seeking in memory the response associated with the signal recognised. The driver decides the type of reaction adapted to the situation. Absence of action interrupts the information processing sequence.
- 4. Seeking in memory for the motor code required to perform the response.
- 5. Execution: the motor process comes into play to execute the response (braking, avoidance, warning sound).
A sixth phase can be added to this model, it concerns a mechanical response from the vehicle whose inertia must be taken into account (response of brakes, steering wheel).

Several laboratory experiments have been performed to measure the reaction time of subjects to a simple signal, the response to which consists in pressing a button or a brake pedal. The data produced by these works cannot be easily transposed from one real driving situation to another in which the driver is subjected to a large number of stimuli simultaneously and permanently. Indeed, when the tasks demanded from the subjects is simplified and the range of potential actions narrows down to a single option, certain steps in the Theios model are not implemented, thereby shortening reaction time. Our review of the questions will therefore only deal with several experiments considered close to real driving conditions; likewise with experiments aimed at comparing speeds between the different types of reaction observed (braking or lateral avoidance of the obstacle).

In a synthesis published in 1986 in the review "Recherche Transports Sécurité", Malaterre [11] cited the works of Barret and Kobayashi [12] who, at the end of the 1960s, used a driving simulator to measure the reaction time of subjects to a pedestrian suddenly crossing the road. The task given to these subjects was to evaluate the speed of the vehicles. After a certain time they saw a pedestrian cross the road without being warned beforehand. The average reaction time of the subjects who succeeded in avoiding the pedestrian was 0.829 s (3 subjects), whereas it was 1.131 s (7 subjects) for those who failed to avoid the pedestrian. Malaterre also cited two studies by Summala [13]: the first took place at night and aimed at measuring the reaction time (through swerving), of a vehicle whose driver was subjected to the illumination of a light on the right shoulder. It required slightly less than 2 s between the illumination of the light and the observation of a measurable displacement. The other experience took place in the daytime, with the aim of measuring the reaction

time (by swerving) of drivers confronted by the door of car parked on the right kerb being opened. The average time taken to swerve was more than 2.5 s.

The hypothesis according to which reaction time increases when a driver has to choose between several types of reaction while simultaneously performing two tasks was demonstrated by the study by Valat et al. [14]. The method used was the double task method, which refers to Broadbent's filter theory of limited channel capacity. This theory is based on the hypothesis according to which the attentional resources used for data processing are limited. During the execution of several tasks, the available cognitive resources can become saturated. If they have reached their threshold, the correct performance of one task will be done at the expense of the second.

The experiment performed by Malaterre and Lechner allowed subjects to generate three types of reaction: braking, swerving or both [15]. 49 subjects took part using a driving simulator. The subjects took 10 minutes to become familiar with the driving simulator at an imposed speed of 90-100 kph. When reaching a junction of two intersecting roads, a vehicle without right of way waiting at a stop sign started and moved from right to left for 1.9 s, then braked suddenly and stopped in the middle of the road. This vehicle therefore represented the obstacle to be avoided by the subjects without being warned. The subjects were able to perform emergency braking, avoidance by swerving or possibly braking followed by swerving .
The reaction times measured were 0.8 s to release the accelerator, 0.8 s to move the steering wheel, and 1 s for braking. The emergency avoidance manoeuvre (swerving) was used far less than braking.

To conclude, the reaction time of a subject confronted by an unexpected obstacle is about 1 s when involving braking and slightly less, 0.8 s, for swerving. The reaction times obtained by Summala [13] in which the subjects reacted by swerving were longer and ranged from 2 s to 2.5 s. The situation therefore affected reaction time and the latter appears to increase under conditions close to a natural car driving task.

It is interesting to compare these elements to the reaction times indicated in the road safety manual of the WRA (World Road Association) of 2003 which gives from 1 to 2.5 s according to the type of environment (urban or rural). The United States, Canada and South Africa recommend 2.5 s, whereas 7 European countries recommend 2 s [17].

3. METHODOLOGY

The method used here is the comprehensive analysis of accident mechanisms of a sample taken from the database of the Detailed Accident Study (EDA) available at IFSTTAR's Accident Mechanisms Research Unit.

3.1 Detailed Accident Studies

The aim of these studies is obtain better knowledge of the mechanisms governing road traffic accidents and situations confronting users [7][16]. It entails the thorough analysis of these accidents by studying all their components (driver, vehicle, infrastructure) and their interactions. The data were collected from an experimental

area covering about 15 km around the town of Salon de Provence in the south of France. Immediately an accident occurred, a multidisciplinary team composed of a psychologist and a technician went to the site and collected the most detailed data possible on the accident. The psychologist held in-depth interviews with the driver and passengers of the vehicle or vehicles. The technician collected data on the road infrastructure and vehicles involved. These elements were then matched and analysed to obtain better understanding of the relations between the different factors involved. Measurement of marks and deformations on the vehicles, calculation of speeds, interviews, the kinematic reconstitution of trajectories, and impact components permitted the fine analysis of the sequence of events composing the accident. Kinematic models of the accident were used for temporal and spatial reconstitution and parameterization. The malfunctions identified of those involved were based on breaking down the accident into a sequence of situations corresponding to models [8].

- The driving situation or pre-accident situation: the "normal" driving situation that includes the objectives, the task to be performed, the driver's expectations. This underlies the strategy adopted close to the scene of the accident.

- The accident situation, which corresponds to the moment of rupture leading to a critical situation. It is usually generated by the occurrence of an unexpected element.

- The emergency situation in which actions are taken to avoid danger immediately the difficulty has been identified.

- The impact situation which signals the failure of the actions taken. Here the nature of the impact and the subsequent events are described.

The result of this approach is a collection of accident cases analysed clinically, incorporating a diagnosis of the mechanisms and factors leading to the triggering, sequence and consequences of these accidents. It is possible to set up thematic studies by matching these monographies on the basis of different selection criteria.

3.2 The sample used

Our sample was composed of 23 accidents collected from 2006 and 2010, processed in the framework of EDA by the investigator and co-author of this article. The EDA contained very rich data that are used more to illustrate the diversity of accidents rather than pretend to direct statistical representativeness. For the analysis, the accidents were classed as a function of the behaviour of the road user having right of way according to situation: driving, accident, emergency. This leads to building a tree structure with branches to different "behavioural families" (see figure 1). The conviction of right of way was identified in the analysis as an accident factor in 18 cases out of the 23, while 5 cases did not include the conviction of right of way .

We analysed the driving strategies of the persons involved by relying on the verbal protocols collected during the interviews held following their accident. The objective was to identify the behaviours and strategies adopted by the drivers by correlating them with items of the road infrastructure. Figure 1 describes the chronology of the events. This figure is simply descriptive and cannot take into account the complexity of the accident. Differentiating the different accident families was only possible after this step and relie exclusively on the data stemming from the EDA.

Initially, we observed the behaviour of the driver as they approached the junction. Were they glancing at the surroundings; were they taking care to watch for other vehicles liable to arrive? Did they slow down when approaching the junction, and modify their speed according to the place. We consider that the emergence of a strong conviction of right of way can be characterised here by several reactions. When approaching the junction, the driver who does not glance at the junction they have to cross and/or who maintains their speed, assumes that they do not have to take care of other vehicles located on a side road, since they consider that these vehicles must give way to their priority. The declarations of right of way drivers on the section of the road approaching the junction illustrate these behaviours signifying lack of observation and maintaining speed: "... *I was on a main road ... I didn't even think about the stop... I continued, sure of myself... I go my way...* ».

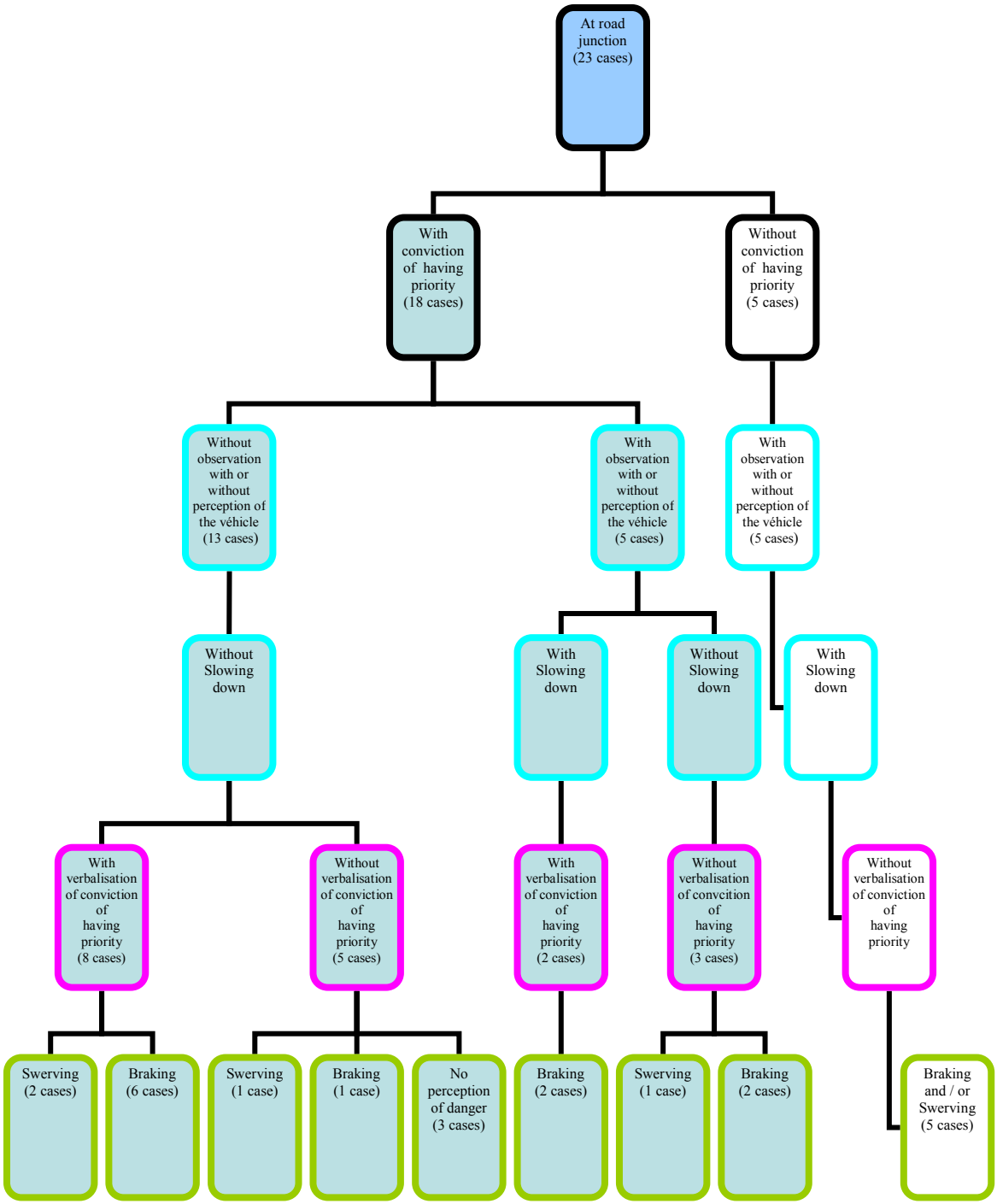

Figure 1 – Classification of accidents as a function of the approach situation (blue), rupture (pink), emergency (green)

The driver with right of way then finds themselves in the accident phase, confronted by another vehicle and obliged to react. The conviction of having right of way, if already present, can be strengthened although it may occur only during this phase. For example, on seeing the other vehicle in the middle of the road, one driver declared "*... he must be crazy, he's crazy!!*". This comment can be interpreted as if the driver considered that the other vehicle impeded their progression, implying that it should not be there and that this third party should react by moving out of the way in order to resolve the situation: "*... I thought that at the last moment, the driver of the*

other vehicle had seen me and that they would have braked". The driver therefore found themselves expecting that the other party involved without right of way would transform the conflictual situation into a normal driving situation, since it was they who were the cause of the malfunction. The driver having priority therefore have available a very short period during which they can react. Insofar as they judged the accident situation in terms of right of way, they waste the short time still left to them during this phase. This hesitation extends reaction time, though we are still in the phase considered to be intermediary between the identification of the signal (phase 2) and seeking in memory the response associated with the signal recognised previously (phase 3), of the sequence of the Theios process [10].

There is a specific condition during which the driver remains blocked while identifying the signal (phase 2), since they wrongly interpret the situation and have not sensed the danger, therefore they do not react appropriately.

In brief, the conviction of having right or way or priority can be expressed either in the approach situation by behaviour conforming to linear progression and non observation of the environment, or in the accident situation through a verbalisation of this conviction of having right of way. Therefore we distinguished four families of users (described further on in the results section). The first family is composed of drivers whose conviction of priority is expressed in the approach situation and in the accident situation. The users of the second family express the conviction of having priority only during the approach situation, while the drivers of the third family only express this conviction during the accident situation. The fourth family is composed of drivers who never express a conviction of having right of way.

4. RESULTS

4.1. First family (8 cases): very strong conviction of having right of way

Generalities
This is the largest family in terms of number. Most of the drivers were driving to carry out a task, either shopping or commuting to and from work from their homes. In every case, the accident occurred either in the municipality in which the drivers lived, or in a neighbouring municipality, thus they travelled by the site of the accident daily and knew it very well. The speeds of the cars approaching the accident were either below or at the regulatory speed limit. Only one driver exceeded the speed limit of 30 kph. Most of these drivers had never been involved in a traffic accident before, and they had all held a driving licence for more than four years. The manoeuvres of non priority road users with which the drivers with right of way were confronted varied. At the junction, the drivers without right of way could come from the right or left before cutting in.
The drivers without right of way had varying characteristics: men and women from 22 to 70 years old. In no case were they committing a violation as they were crossing the junction slowly.

Conviction of having right of way
The drivers having priority had a very strong conviction of their right of way as they expressed it in both the approach and accident situations. When approaching the junction, they did not glance at its environment and did not slow down. During the

accident phase, at the moment when the non priority vehicle was observed, they claimed a right of way they felt was greatly in their favour. This is demonstrated by the verbal protocols described below. Most of the drivers reacted by braking or by an attempt at avoidance. It is noteworthy that one female driver in this family hooted in order to reassert her conviction of having right of way in view to getting the non priority vehicle out of the way, just before reacting by braking.

Declarations on the period when approaching the junction were obviously poor since the drivers did not glance at the road and did not slow down, thus the drivers having right of way reached the junction without really being aware of it. They behaved as if there were no break in the infrastructure by continuing on their way on a straight road without a junction. However, they are voluble immediately they describe their reaction after detecting danger. They frequently expressed themselves in interrogative form together with a judgement *"What's he doing there, that guy must be mad?!!... Ah what's she trying to do to me?... What's she doing? Is she moving out? Is she moving forward?"* The interrogative form used by the drivers signifies that they did not consider it possible for another vehicle to make this manoeuvre. They judged the behaviour of the vehicle advancing on the road to be abnormal. It was at this very moment that they lost the time they could have devoted to reacting. These drivers then expressed their very real expectation that the driver without priority would correct the situation. It was up to the other to react, to restore the situation in order to remove the danger. They again lost a little more time since they no longer reacted during this period of expected correction: *"She's going to stop, she's going to brake... I hooted while saying to myself that she's going to stop... I thought she would have braked..."*. What is more, their initial aim was to continue on their way and escape the situation since it was up to the other driver to react. One driver went as far as saying *"... I'm dead, but I'm not in the wrong*." He justified his passiveness by reasserting his right.

In brief, the drivers in this family strongly asserted their right of way in both the approach and accident situations. The distance of visibility was sufficient to have given them time to react and avoid the accident. However, they transferred full responsibility for the conflictual situation to the driver without right of way and thus expended the space-time allowance they had to react.

Reflections on layout

The road junctions were located either in the open country or in open outer urban areas. The priority roads were major routes occupied by heavy traffic. They were generally former trunk roads. In the accidents in which drivers with priority braked, intervisibility distances were quite far (from 60 m to 200 m at the site of the accident), the speeds declared and confirmed by the kinematic reconstitutions were high (in one case a car was travelling at 120 kph). The calculation of the times available for priority drivers ranged from 4.5 to 5.5 seconds that were wasted. This value, close to 6 seconds, shows that the accident could have been avoided if the priority driver had not "pushed" their claim to the right of way so far. From the standpoint of infrastructure, modifying the layout of the priority road would not change anything, no additional warning message (signposts or road markings) would be effective for drivers claiming priority whatever the consequences. Although changing the layout of a main road is hardly envisageable, action to inform road users (in the framework of

driving lessons to obtain a driving license or an awareness campaign) deserves reflection.

Analysis of the accidents highlights poor understanding of the layout of road junctions by the drivers without right of way. Young drivers were involved in accidents at "non standard" junctions while elderly persons were involved in accidents at major junctions with layouts (several lanes, central traffic islands).

The surface area covered by junctions is large and modifying a layout is always possible, especially in the open countryside. However, in all cases and in addition to simplifying road junctions, layouts could be subject to specific improvements by eliminating obstacles to visibility due to vertical signalling or road marking or due to the immediate environment: cutting hedges, displacement of urban furniture. These actions require few resources but allow improving inter-distance visibility and giving "more time" to users without right of way.

4.2. Second family (5 cases): careless drivers

Generalities
In this case the drivers with priority belonged to a relatively homogenous group with the following characteristics: they were commuting on the route they took every day or frequently, they were all over-familiar with the site of the accident. The latter was at least 5 km from their home. All the drivers had held their driving licenses for at least five years, and they were approaching the site of the accident either at the regulatory speed limit, or 5 kph above it. Those who had slightly exceeded the regulatory speed at the time of their accident, without being guilty of recurrent speeding, had been fined for one or more speeding violations since they had obtained their driving license. The speed at which they drove could be explained by their excellent knowledge of the site of the accident, which led to over-confidence and thus a lower level of attention by the driver. Without consciously wanting to exceed the authorised speed limit, the driver failed to monitor their speedometer.

The users without priority did not know how to interpret the sites due to the complexity of the layout or the signalling installed. The heterogeneity of the priority system can be emphasised (stop signs, give way signs, priority on the right signs, etc.) which disturbed the driver during the final kilometres of their trip.

Conviction of priority
This family groups drivers whose conviction of having right of way is mainly expressed in the approach situation. Indeed, they assert their status by behaviour that included maintaining their speed near the road junction and non vigilance. In spite of the imminence of the accident, most of these drivers remained persuaded that they must not glance at the road and thus never detected the danger.

When approaching the accident site, the drivers did not glance at the road and did not slow down. In the accident situation, they did not verbalise the feeling of having priority since most of them had not even seen the danger, that is to say that before impact, they had never detected the vehicle without right of way. Everything happened as if they were persuaded that is was the other users who were obliged to

take care and they saw no other vehicle. For the two drivers who finally did detect danger, they could only react late by trying to avoid the accident or by braking.

The verbal productions of the drivers having priority in this family showed that they emphasised the fact that they did not glance at the road. They insisted on the fact that they considered that they did not have to perform this active task of observation. This behaviour was conscious as well as being voluntary. Thus one driver explained his driving before reaching the junction, " … *I don't out look for the moon at midday*… *There's a stop sign so I don't even think about it … I don't glance at what's happening at the roadside … There' a "give way" sign so I have right of way"*. The two drivers who finally saw a vehicle displayed a feeling of surprise when the adverse vehicle "popped" into view. They underlined the speed at which this vehicle appeared in front of them " … *it arrived like a rocket … suddenly I saw a car in front of me*". These drivers also displayed a certain amount of passiveness " … *my path was blocked*…". They considered themselves to be victims of the adverse vehicle.

Actions on the road layout
All the road junctions were located in outer-urban areas. In the case where the user with right of way reacted to a rupture situation, the approach was fast and clear of obstacles. Taking into account the speeds travelled and especially the short final time for reaction, the accident could not be avoided dynamically.

In the case where the user with right of way did not have time to react, the junctions were large and relatively complex, allowing heavy flows of traffic at the periphery of the town. Visual interference can be considerable (advertising, signalling of information, direction, instructions, road markings, number of lanes, etc.).

Regarding the topography and/or the configuration of the layout, the inter-visibility distances were short (from 15 to 50 m). Combined with the declared speeds of about 55 kph, corroborated by kinematic reconstitution, the times available to the driver with priority were from 1 and 3.3 seconds. By referring to the different theoretical phases of reaction time described at the beginning of this article, it can be seen that avoiding the accident was impossible.

In certain cases, given that the configuration of the sites makes improving inter-visibility difficult (buildings, etc.), other actions must be analysed: simplification, uniformisation, making the loss of right of way clearer. Indeed, the surface areas of the road junction layouts are ample and recommendations to simplify layouts such as roundabouts could be made. Less expensive actions could be performed regarding the accident mechanisms highlighted, by standardising priority systems more than systematically installing "Stop" signs (intended to reassure). Adjustments that might appear mere, though nonetheless important, details could be made to the layouts, by moving the vertical signalling (traffic island bollards, etc.) in order to improve visibility at specific points or eliminate ambiguities. The maintenance or elimination of hedges are also mentioned.

4.3. Third family (5 cases): rigid drivers

Generalities
Four out of five accidents share similar characteristics in terms of trip, speeds travelled when approaching the accident, knowledge of the accident site and, lastly, driving experience, which is an important factor. The drivers were very experienced drivers. They had held their driving licences for more than eight years and had rarely, if at all, committed violations of the highway code since obtaining their driving licences.
They were making short trips that could be between two neighbouring municipalities of within the same municipality. They knew the itinerary they used very well, having taken it at least once a week for several years. They lived close to the site of the accident so were very familiar with the surroundings. The speeds at which the drivers drove their cars when approaching the road junction where the accident occurred was at least 5 kph lower than the regulatory speed limit.

However, one case was very different. The driver with right of way was young and had obtained his driving licence only three weeks beforehand. He did not often travel by the site of the accident as he lived more than 50 km away. Despite this, the driver appeared, according to his declarations, to be familiar with the site of the accident, "… *I know this road by heart*". It was the impression that the driver had of knowing the scene of the accident that appeared to influence his behaviour. This could be explained by regular passages by the site as a passenger in a vehicle previously.

The drivers without right of way arrived from both left and right of the junction. They were crossing it or turning left or right. The reasons for their trips were: practical (shopping, accompanying or working), leisure, commuting. Certain drivers had never had a traffic accident, while others had already been victims of traffic accidents for which they had been considered either responsible or not responsible. The driving situations of these drivers also differed: an elderly driver deliberately failed to stop at the stop sign, another stopped too early before reaching the junction, one person saw the car with priority and thought they had time to get by, several people (the majority) did not understand the road junction. Analysis of accident mechanisms shows that road users can stop at "Stop" signs without really understanding how the junction is configured. Whatever the case, they all crossed the junction at slow speed.

Conviction of priority
For the drivers of this family, the feeling of priority only occurred during the accident situation. These drivers clearly detected a vehicle but delayed considering it as a potential danger. They were rooted in their convictions of regulatory priority and waited for the other party to conform to the regulation. However they could have reacted more quickly since their visibility was adequate.

Certain drivers are liable to slow down when approaching a road junction. In a rupture situation, they develop a feeling of priority and react by trying to avoid the adverse vehicle or by braking.

The verbal productions of all the drivers of this family show that, as soon as they had glanced at the layout, perceived the adverse vehicle and really taken in its presence, they expressed a strong claim of having priority: "… *I paid more attention… I wasn't*

careful enough, … I go my way … I continued without thinking about it … It wasn't up to me to stop…". These drivers with priority consider that they did not have to change their behaviour to adapt to the presence of the adverse vehicle at the road junction. They continued by expecting the other driver to conform to "regulatory" behaviour until the end: "… *she's has to stop … I didn't think that it wouldn't stop*… ". The vehicle that did not yet represent a threat, legitimately owed them their priority. The drivers never considered that the vehicle would enter the junction. They then expressed their conviction of having priority more directly " … *in any case, I had right of way … I was in the right, having priority … I went straight ahead* … ".

Actions on layout
The users with priority were on a long stretch of straight road before the junction (from 200 to 600 metres), the junctions were visible and clearly detectable from 70 to 100 m and, considering the speeds travelled, the drivers had from a 4 to 6 second to react. However, beyond these well calibrated distances, we highlight in the analysis of the accident sequence, areas of blocked visibility that caused breaks in intervisibility (a row of trees with tall trunks, buildings, indication and instruction panels, traffic island bollards, lighting masts, parked vehicles, etc.). This loss of visibility did not occur continuously in the approach phase and the user with right of way could have reacted more appropriately if they had not strengthened their conviction of having priority.

The junctions were diverse in terms of layout, installed on urban boulevards or in the open country. They were equipped with Stop signs. It is noteworthy that in two cases, the Stop signs were installed at a distance from the junction, so that drivers that want to stop have to advance as much as possible to ensure they have maximum visibility. This configuration encourages drivers to try and get through as they can or at least pushes them to cross the junction and not stop at the same point as the panel. Perhaps it also pushes them to take a greater risk when crossing insofar as they consider themselves to be in an uncomfortable situation when beyond the panel.

4.4. Fourth family (5 cases): absence of conviction of priority

This family includes drivers who have not developed a conviction of having priority. These drivers glance at the junction and slow down when approaching it. In an accident situation, they do not express a conviction of having priority, they react quickly by braking followed or not by swerving.

The notable difference between the verbalisations of these drivers without conviction of having priority and the other drivers in our sample, is that they strongly assert having been seen by the non priority drivers. These drivers consider that the fact of being visible to the non priority driver made them feel safe when crossing the road junction. These drivers consider that not being sufficiently visible by the other party represents a genuine danger. They accentuate their caution by increasing their vigilance and reducing their speed. Confronted by the accident situation, their absence of conviction of priority causes them to react as soon as they perceive the obstacle and in the way they think most appropriate.

Analysis of the verbal protocols underlines that they feel apprehension, without being able to explain the reason for this suspicion when approaching the site. This was made evident by the fact that they reduced their speed when approaching the road junction " … *I took my foot off the accelerator pedal... I must have been doing 85 kph, and slowed down to 80 kph... I started to brake to slow down... I don't drive fast on this road*...". Some had witnessed accidents at this site, or had heard reports of accidents occurring there "… *I'm careful nonetheless because everyone says that this junction's dangerous... I feel nervous every time I start getting close to this junction*…". The drivers then declared that they continued glancing at the site, and as soon as they had detected danger, they reacted as quickly and efficiently as possible "... *I watch out. I never know, even if I do have right of way … I'm always really careful at this junction … but the other car didn't stop... it didn't pause... I saw that the other driver wasn't looking at my car... I braked as hard as I could*...". It is noteworthy that these drivers feel that it is important to be seen by the drivers of the adverse vehicle. The driver knows that they have priority status without them feeling that this gives them the conviction characterising the drivers of the other families. The cause of these behavioural differences appears to be attributable to the environment.

Actions on the layout
The design of the infrastructure is an important component in the genesis of the accident. We attribute significant influence to lack of visibility. Indeed, these cases of poor inter-visibility (less than 50 m) permit explaining the behaviour of the drivers through their lack of conviction of having priority. The drivers all knew the road junction since they passed it regularly, even daily. They know that non priority drivers wanting to cross the intersection are unable to see them correctly. Likewise, they are unable to obtain an optimal view of these drivers. Low inter-visibility appears to be the main concern with respect to emergency and/or accident situations, whereas for the previous families the issue of inter-visibility was involved in driving and in accident situations.

Sometimes, it can be difficult or even impossible to act on the infrastructure when examining the configuration of the site concerned. However, in a few cases, increasing inter-visibility by better maintenance of slopes and trees (cutting and trimming) would improve the situation. Similarly, stricter town planning rules would permit reducing the heights of fences and increase the distance between buildings and the edges of plots; also, the regular trimming of hedges could be enforced to ensure good visibility.

5. DISCUSSION AND CONCLUSION

The objective of this work was not to demonstrate and prove, but to describe and understand. This understanding and explanation belong to a heuristic approach that can only be achieved through the fine degree of analysis obtained by the Detailed Accident Studies. This makes possible the development of hypotheses and research much closer to real road safety problems. Advantages can be obtained through understanding (by revealing difficulties) and through application (understanding problems in their contexts is a requisite for defining appropriate measures).

This research has led to generating an accident typology and explaining how the conviction of having right of way could be one of the factors causing or aggravating accidents. Better understanding of the situation by the driver with priority and especially by reducing the strength of their conviction of having priority could have led to avoiding certain accidents or at least greatly reduced the violence of impacts. In most cases this behaviour is not correlated with speeding, except on large open infrastructures. We confirm here the image of a "waste of space-time credit" (Girard, 1987) that can be significant [5]. The corollary of this is that long straight stretches of road and high visibility when approaching road junctions, in the case where thyese factors can aid safety, can be counter-effective. Analysis of inter-visibility must be performed progressively as the accident proceeds. Non priority vehicles crossed the junction when their drivers failed to understand the layout. Whether they crossed the junction without stopping or whether they stopped and restarted, the possibility of misunderstanding road junctions is always present.

The Detailed Accident Analyses allowed us to confirm our hypothesis regarding the behaviour of drivers and road junction configurations. Despite this, we did not obtain very precise measurements of reaction time. On the basis of nonetheless very detailed data, we demonstrated that RT increases with the conviction of priority, but although it is difficult to provide data in figures. Measuring the loss of time caused by a conviction of priority requires tools unavailable at the accident sites. The approximations highlighted for the parameter in the accident reconstitutions, shows the difficulty of making precise estimations. We require stricter frameworks in which to conduct the experiments to obtain an idea of the range in which these reaction times exist and shed light on paths for improving layouts, both in their design and space as well as in managing road facilities.

In our view, an interesting path for development is to set up experiments by using a driving simulator to study the links between infrastructure configuration and the conviction of right of way:

- Improving knowledge of reaction time in relation with the conviction of having priority, would allow more precise definition and examination of the bracket of 4 – 6 seconds used in road infrastructure guides [17].
- Analysis of the elements of misunderstanding of existing road junction layouts leading to these accidents, would aid the design of these infrastructures.

The driving simulator developed at the IFSTTAR Accident Mechanisms Research Unit on which we test the effects of the driving experiment, psychotropic drugs and environmental elements could be a useful tool for obtaining information in this domain [18][19].

Education and communication relating to the potential danger of the conviction of having right of way are also paths that can be investigated. Insofar as drivers with priority know the sites in question very well, a message whose principle meaning is "it's not because you know this site very well that others do too," does not appear out of place to us. It would benefit all road users.

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