Science topic n°6

How can **pedestrian safety** be improved?

Transport and mobility

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HOW CAN PEDESTRIAN SAFETY BE IMPROVED?

By Pierre-Jean Arnoux,
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Although recent years have seen a considerable drop in the number of casualties on roads, in proportional terms pedestrians are still at particularly high risk, both in developed and emerging countries. IFSTTAR's efforts to improve the safety of so-called "vulnerable users" involves several scientific disciplines and analysis at various scale levels.

Prior to the accident, analysing the behaviour of the user in the environment

This analysis suggests ways of improving the organisation of transport systems, both with regard to highway design and street furniture. Considerable study is devoted to elderly persons, whose perceptive, cognitive and motor capacities may be impaired. The use of simulators allows investigating the influence of these impairments and may have the potential to become a tool for relearning. This approach relates both to pedestrians, in order to improve their ability to move around within the urban space, and drivers for whom the attentional ability to detect pedestrians in time and perform an appropriate manoeuvre in time is essential.

A large number of issues

An analysis of the accident scenario is essential in order to develop active safety devices with the potential of avoiding the accident or warning the driver while at the same time allowing for the reactions of the pedestrian.

Studying the physical vulnerability of the pedestrian by gaining an understanding of the mechanisms responsible for injury is also a concern. This makes it possible to influence vehicle design by proposing appraisal standards.

An approach combining experimental tests with numerical simulations permits broadly based, realistic investigations taking account of a large number of parameters that apply to the vehicle (shape, location of impact point, speed) and the pedestrian (size, position, posture). The value of developing both active and passive countermeasures for cars is therefore obvious. The concept of integrated solutions, which combine active systems and passive safety, is one that opens up considerable opportunities for IFSTTAR.

Post-accident analysis and clinical care of casualties

This stage is essential in order to provide input for our research topics. Statistical analysis of trauma (including the follow up of casualties and monitoring their rehabilitation) or alternatively the detailed analysis of accidents gives valuable data for identifying risk factors or the conditions under which the accident occurred. We have thus been able to show that risk exposure is higher for men than for women1. The youngest individuals and the elderly are undeniably groups with a high risk, with different injury typologies.

IFSTTAR conducts wide-ranging research, in some cases in the framework of national and international collaboration, in order to understand the vulnerability of pedestrians and improve their safety. All in all, IFSTTAR is able to deploy its research capabilities in a very large number of areas. The institute can thus propose solutions for prevention and training, improving infrastructure and, lastly, the physical protection of this group of road users.

1. LBA: Laboratory of Biomechanics and Application
2. TS2: Transport, health, safety Department

Further readings

Martin J.-L., Lardy A., Laumon B., Pedestrian Injury Patterns According to Car and Casualty Characteristics in France, Ann Adv Automot Med. 2011 October; 55: 137–146.
Mo FH, Masson C, Cesari D, Arnoux P.-J., Coupling Lateral Bending and Shearing Mechanisms to Define Knee Injury Criteria for Pedestrian Safety. Traffic Inj. Prev. Mar 2013;14(4): 378-386.
Mo F, Arnoux PJ, Zahidi O, Masson C., Injury thresholds of knee ligaments under lateral-medial shear loading: an experimental study. Traffic Inj Prev. 2013;14(6): 623-9.
Mo F., Arnoux P.-J., Cesari D., Masson C., Investigation of the injury threshold of knee ligaments by the parametric study of car-pedestrian impact conditions. Safety Science. 62, 2014, 58–67.
Mo F., Arnoux P.-J., Cesari D., Masson C., The failure modelling of knee ligaments in the finite element model. Int. J. Crashworthiness. 2012;17(6): 630-636.
Mo F., Arnoux P.-J., Jure J.-J., Masson C., Injury tolerance of tibia for the car–pedestrian impact. Accident Analysis & Prevention. 2012;46(0): 18-25.
Peng Y., Chen Y., Yang J., Otte D., Willinger R., A study of pedestrian and bicyclist exposure to head injury in passenger car collision based on accident data and simulation. Safety Science 2012, 50 (9): 1749-1759.
Peng Y., Deck C., Yang J., Willinger R., Effects of pedestrian gait, vehicle-front geometry and impact velocity on kinematics of adult and child pedestrian head, International Journal of Crashworthiness 2012, 17(5), 553-561.
Peng Y., Deck C., Yang J., Otte D., Willinger R., A study of adult pedestrian head impact conditions and injury risks in passenger car collisions based on real world accident data, Traffic Injury Prevention, 2013.
Peng Y., Yang J., Deck C., Willinger R., Finite element modeling of crash test behavior for windscreen laminated glass, International Journal of Impact Engineering (57), 27-35, 2013.

Interview

Which safety system for pedestrian protection ?

Listen to Thierry Serre from LMA (in French)

Credit: Ifsttar

1 IDENTIFYING THE CHARACTERISTICS OF PEDESTRIANS INVOLVED IN A CRASH

By Jean-Louis Martin,
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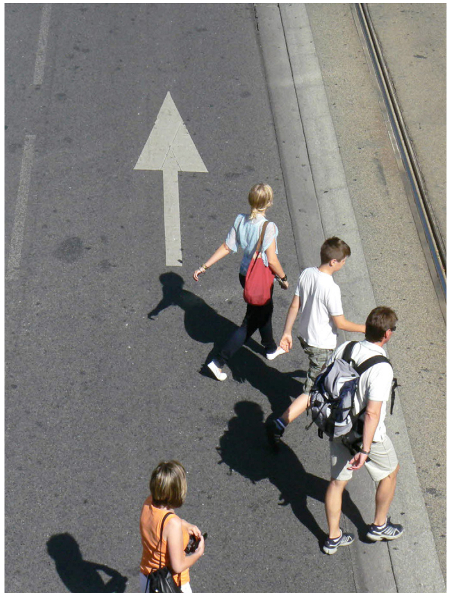
TS2[1] Department, UMRESTTE[2]

Between 2000 and 2010 pedestrians accounted for about 27% of those killed in road traffic accidents in the European Union[3].
In France, 489 pedestrians were fatally injured in 2012[4], amounting 13.4% of all road fatalities. Based on an accurate description of the injuries they sustained and an internationally validated injury severity coding system, it is estimated that 25,000 pedestrians were injured in that year, 4,000 of them seriously.
Pedestrians are therefore the fourth most crash-involved group of road users after motorists, the riders of powered two-wheelers and cyclists. There has been a downward trend in the number of crash-involved pedestrians in the last ten years or so[5].
This change occurs at a time when there has been a slight increase in the number of powered two-wheelers and a spectacular reduction in the number of crash-involved motorists.

Who are the pedestrian casualties?

As is the case with the other categories of road users, most crash-involved pedestrians are young. For both males and females most crash-involved pedestrians are in the 10-19 year old age group. Nevertheless, the over-70s are over-represented in relation to their number in the population. More than 50% of the crash-involved pedestrians in this age group are over 85 years of age.



As with all groups of road users, pedestrian injury severity increases with age, particularly after 64 years of age, both in terms of lethality and injury severity.

The location of injuries varies with pedestrian profiles

Seventy-three percent of pedestrian casualties who have sustained at least one non-minor injury have a fracture. The most common body regions for these are, in order, the lower limbs, the head/face/neck and the upper limbs. More specifically, the most frequently injured parts of the lower limbs are the legs and knees as these are directly impacted by the striking vehicle.
On average, men are more severely injured than women. They sustain fractures less frequently than women, but their internal organs are significantly more often injured. They also receive more impacts to the head, thorax and legs.
However, women sustain more injuries to their upper limbs, knees and, above all, pelvis, for which the risk is twice that for men.
The majority of fatal injuries, and a major proportion of severe injuries, are to the head and thorax. This is the case for all age groups.

Appropriate countermeasures?

Consumerist tests, like the **EuroNcap** tests, encourage manufacturers to improve their vehicles in order to reduce injury severity in the case of an impact with a pedestrian. The findings of such tests, which currently focus on head, lower limb and hip injuries, are consistent with the studies conducted at IFSTTAR. They could nevertheless be improved by the addition of a specific test for thoracic injury as the thorax is, after the head, the body region with the highest risk of severe, or even fatal, injuries.

> **“As is the case with the other categories of road users, most crash-involved pedestrians are young. For both males and females most crash-involved pedestrians are in the 10-19 year old age group.”**

1. TS2: Transport, health, safety Department
2. UMRESTTE: Epidemiological Research and Surveillance Unit in Transport, Occupation and Environment
3. WHO. WHO Global Safety, Decade for Action: Word health Organisation; 2013.
4. ONISR. La sécurité routière en France, Bilan de l'année 2012 : *La documentation française* ; 2013.
5. Martin JL, Lardy A, Laumon B. Pedestrian Injury Patterns According to Car and Casualty Characteristics in France. 55th Annals of Advances in Automotive Medicine (AAAM) Annual Conference; 2011 October 3-5, 2011; 2011.

2 UNDERSTANDING ACCIDENT PROCESSES

By Thierry Brenac,
Researcher
TS2[1] Department, LMA[2] Laboratory

To develop accident prevention measures it is helpful to understand the processes involved in the sequence of events and situations which lead to collisions.
A very wide range of processes are involved in pedestrian accidents[3].
A few recurring problems, which are frequently factors during an accident can nevertheless be identified.

The main dangers facing pedestrians

Firstly, obstacles to visibility play a decisive role in many accidents. In particular, when a pedestrian steps out from between two stationary or parked vehicles, an oncoming driver has very little time to react, even when travelling at moderate speed.

Suddenly crossing the road when excessively focused on a goal (catching a bus, meeting an acquaintance on the other side of the road, etc.) is another frequent characteristic of pedestrian accidents, particularly in the case of children and adolescents[4]. However, other attentional or information seeking deficiencies may also be involved. For example, at an intersection motorists need to give way to other vehicles which may use a great deal of their attention, meaning that pedestrians go unnoticed. Less often, unusual design characteristics (for example some contraflow lanes) may cause pedestrians to wrongly identify the direction of traffic and look the wrong way when crossing.

In addition, motorists often fail to notice pedestrians at night-time, even when there is street lighting. This is even more common when it rains at night. Under these conditions a pedestrian crossing the road may not be seen by a motorist and knocked down. Furthermore, both the pedestrians and drivers involved in night-time accidents are more likely to have consumed alcohol. Outside built-up areas, the few pedestrians walking along the carriageway are at very high risk as drivers may not see them and impact them at high speed because their vision is disturbed by the headlamps of oncoming vehicles. Such accidents are particularly serious. Another category of severe accident involves pedestrians who are occupied around broken down vehicles on high speed roads (motorways, dual carriageways, etc.), who are noticed too late by a driver.

Specific problems with some types of vehicles

Goods vehicles, buses and powered two-wheelers sometimes play a specific role in pedestrian accidents. Goods vehicles often impact pedestrians when reversing because their drivers usually have restricted rear visibility. Because of their size, HGVs and buses are more likely than cars to knock pedestrians down when making turning manoeuvres. Also, due to their size, buses and trucks often impede visibility causing pedestrian accidents[5].

Powered two-wheelers are more likely than cars to impact a pedestrian[6]. In particular, when they drive fast next to long queues of stationary vehicles, there is a high risk of an impact with pedestrians crossing the road, as the queues of vehicles obstruct visibility.

Overall, the in-depth analysis of pedestrian accidents suggests many possible ways of making improvements, in particular through road design, the organisation of transport systems, vehicle design and road user education and training.

1. TS2: Transport, health, safety Department
2. LMA: Laboratory of Accident Mechanism Analysis
3. Scénarios types d'accidents impliquant des piétons et éléments pour leur prévention, par T. Brenac, C. Nachtergaële et H. Reigner. Les Collections de l'INRETS. Arcueil : INRETS (2003).
4. « Insécurité routière des jeunes piétons : processus d'accidents et stratégies de prévention », par T. Brenac. Territoire en mouvement, t. 2008, n° 1, p. 14-24 (2010).
5. "The indirect involvement of buses in traffic accident processes", par T. Brenac et N. Clabaux. Safety science, vol. 43, n° 10, p. 835-843 (2005).
6. "Powered two-wheeler drivers' risk of hitting a pedestrian in towns", par N. Clabaux, J.-Y. Fournier et J.-E. Michel. Journal of Safety Research, vol. 51, p. 1-5 (2014).

Credit: Ifsttar

3 OBSERVING PEDESTRIAN REACTIONS WHEN THERE IS A RISK OF AN IMMINENT IMPACT

By Thomas Robert,
Researcher
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Pedestrians account for approximately a quarter of the persons killed in road traffic accidents (ONISR data). In most cases the cause is a collision with a vehicle. To try to reduce the number of fatalities, vehicles are now designed in a way that limits the severity of an impact. Currently, devices that enable vehicles to detect and try to avoid pedestrians are being developed (automatic braking and automatic steering systems). However, currently these measures are tested and evaluated for extremely simplified situations, which generally ignore the reaction of pedestrians to the accident and the variety of situations which can occur. In most cases, pedestrians have the time to see the vehicle that is likely to hit them and react to the imminent danger. The nature of these reactions is, however, relatively little documented. IFSTTAR is therefore studying the reactions of pedestrians, both young and elderly, who are crossing the road when a vehicle appears at high speed and threatens to impact them. More precisely, the investigation concerns the effects of this reaction on the level of the risk of impact and the possible consequences of an impact.

An experiment to observe pedestrian reactions

The subjects take turns to move within a virtual environment which simulates a street with a fleet of moving vehicles. The subjects are unaware of the purpose of the study and are simply instructed to cross the street while avoiding vehicles. During one of these crossing manoeuvres, the simulator generates a rapidly moving vehicle, together with the noise of an accident. The reaction of the individuals is measured by a number of sensors. In particular, a movement analysis system[3], similar to those used in the video games and cinema animation industries, quantifies subjects' movements, especially their attempts to avoid the vehicle and their posture at the time of the virtual impact.

The avoidance strategies to be considered

This experiment highlighted the importance and the frequency of pedestrian reactions when faced with the risk of an imminent impact. We can identify three major vehicle avoidance strategies:

- The attempt to avoid the vehicle by speeding up;
- The attempt to avoid the vehicle by moving backwards;
- No attempt to avoid the vehicle, just protection reflexes (for example protecting one's head with one's arms).

These reactions have a considerable influence on the pedestrian's trajectory between the moment when the scenario is initiated or the moment when the pedestrian is detected by an automatic pedestrian avoidance system and the moment of virtual impact.

These reactions have a considerable influence on the pedestrian's trajectory between the moment when the scenario is initiated or the moment when the pedestrian is detected by an automatic pedestrian avoidance system and the moment of virtual impact.

Influence of the reaction on injury risk

A wide variety of postures as well as some significant avoidance strategies were observed in the course of this study. IFSTTAR's researchers therefore attempted to find out if the impact conditions affected pedestrian injury risk. Currently, as far as pedestrian impact is concerned, vehicles are only evaluated with regard to an impact with a pedestrian in a standardised pedestrian position. We therefore need to make sure that these standard test conditions are appropriate.

Using a digital model, the injuries resulting from a pedestrian-vehicle impact were evaluated for the various experimentally observed postures and virtual impact speeds as well as for the standard test conditions. It was shown that injury risk is extremely dependent on the impact conditions. However, the estimated risk under standard conditions was higher than that estimated in 95% of the experimental conditions. This therefore tends to show that the current standard test conditions provide a good starting point.

1. TS2: Transport, health, safety Department
2. LBMC: Biomechanics and Impact Mechanics Laboratory
3. The software used to create the virtual environment was developed by the LEPSIS laboratory in the COSYS Department. This experiment was carried out in the framework of the legislation concerning the protection of persons in biomedical research and was therefore approved beforehand by the Institute's Ethics Committee, the Consultative Committee on the Protection of Persons in Biomedical Research and the National Agency for the Safety of Medication and Health-related Products (ANSM).

Further readings

Cavallo, V., Lobjois, R.7 and Vienne, F., (2006) The interest of an interactive road crossing simulation for the study of adaptive road crossing behaviour. Proc. 1st Driving Simulation Conference Asia-Pacific. Tsukuba, Japan.

A. Soni, T. Robert, and P. Beillas, Effects of pedestrian pre-crash reactions on crash outcomes during multi-body simulations, in Proceedings of the 2013 International Research Council Of Biomechanics of Injury Conference, 11-13 September 2013 – Gothenburg (Sweden), 2013, pp. 762–776.

A. Soni, T. Robert, F. Rongieras, and P. Beillas, Observations on pedestrian pre-crash reactions during simulated accidents. Stapp car crash journal, vol. 57, pp. 157–183, 2013.

Video

Examples of typical reactions observed and reproduced by a computer manikin:

◀ Attempt to avoid the vehicle by speeding up.

Immobility or hesitation ▶ between the first two strategies.

◀ Attempt to avoid the vehicle by moving backwards.

Contact: This research was carried out by A. Soni, T. Robert, P. Beillas and F. Rongieras of the LBMC in the TS2 Department, with the participation of D. Ndiaye and F. Vienne of the LEPSIS Laboratory in the COSYS Department. Anurag Soni's reasearch was financed by the European Commission as part of the Marie Curie action «Pedestrian pre-crash reactions and their effects on crash outcomes». Details about the European project on the Cordis website.

4 UNDERSTANDING PEDESTRIAN VULNERABILITY AND IMPROVING PROTECTION: THE CASE OF CHILD PEDESTRIANS

By Damien Montoya,
PhD Student
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According to IRTAD, in 2012, 115 children under 14 yearswere killed on French roads, 36 of them were pedestrians. Protecting children is therefore an important issue and we can well ask if the available protection solutions, which were developed for adults, are suitable for the morphology of children. By using dedicated virtual models, we can predict the injuries sustained by a child pedestrian involved in an accident according to the shape of the vehicle.

Accident study and epidemiology

In France, after the vehicle passengers, pedestrians are the largest group of child road traffic accident casualties (IRTAD). The typical injured child pedestrian is six years of age[3], was injured while running across the road outside a pedestrian crossing or when emerging from between two parked vehicles[4]. In most cases the child is injured by a light vehicle travelling at an average speed of 26.2 km/h[5]. The most common injuries sustained are to the head (cerebral contusion, subdural haematoma), the torso (spleen injuries, haemo- or pneumothorax and the lower limbs (fractures)[6,7].

Computer-based accident reconstruction

The first stage was to study how the shape of the front of the light vehicle affected the typical injuries that occur when a child is impacted. To do this a numerical study was performed in order to reconstruct a large number of accidents. This study made it possible to modify the conventional geometrical parameters of the front of a light vehicle (the height of the bumper above the ground, the distance between the base of the bonnet and the bumper, the height of the bonnet, the angle of the bonnet).

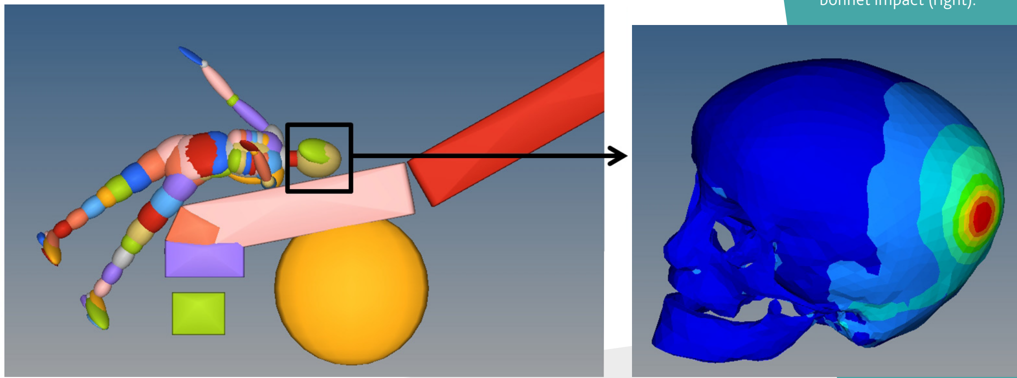
To study the influence of vehicle shape on the child, different vehicle models were generated automatically. The accident between the vehicle and a model of a child pedestrian was then simulated on two scales.

First, simulation was performed at the overall scale by simulating of the whole accident. The model used was representative of a six year-old child and provided the kinematics of the accident and all the injury criteria. Second, it was performed at the local scale, for example, the impact between the head and the bonnet. In this case, a representative bio-accurate model (FEMOCS6) of a 6 year-old child[8] was used to obtain information on the injury mechanisms[9]. The selected contacts involved the body segments that in reality sustain the highest severity injuries (head/bonnet, abdomen/bonnet and upper limbs/bumper).

This system allows to predict injuries and provides particularly useful results. In the near future it could help motor vehicle manufacturers to design vehicles that provide better protection for child pedestrians.

1. TS2: Transport, health, safety Department
2. LBA: Laboratory of Biomechanics and Application
3. H. Fontaine, Y. Gourlet, and A. Ziani, « Les accidents de piétons: Analyse typologique » Rapp. INRETS, nº 201, May 1995.
4. DiMaggio C, Durkin M. Child Pedestrian Injury in an Urban Setting Descriptive Epidemiology. Acad. Emerg. Med. 2002.
5. The FEMOCS6 model wasdeveloped in the Laboratoire de Biomécanique Appliqué de Marseille, UMRT24 Ifsttar/Aix-Marseille Université. B. Y. Henary, J. Crandall, K. Bhalla, C. N. Mock, and B. S. Roudsari, "Child and adult pedestrian impact: the influence of vehicle type on injury severity," Annu. Proc. Assoc. Adv. Automot. Med. Assoc. Adv. Automot. Med., vol. 47, pp. 105–126, 2003.
6. Demetriades D, Murray J, Martin M, Velmahos G, Salim A, Alo K, Rhee P. Pedestrians injured by automobiles: Relationship of age to injury type and severity. J. Am. Coll. Surg. 2004.
7. R. Y. Peng and F. S. Bongard, "Pedestrian versus motor vehicle accidents: an analysis of 5,000 patients," J. Am. Coll. Surg., vol. 189, nº 4, pp. 343–348, Oct. 1999.
8. F. Coulongeat, T. Serre, A. Navarro, M. Behr, and L. Thollon, "Development of a finite element whole-body model of a 6-year-old child for safety," J. Biomech. Eng, 2012.
9. Coulongeat F. Modélisation numérique de l'enfant: application en accidentologie routière, Thèse de Doctorat, Aix-Marseille Université.

▼ Overall simulation of the accident (left) and local simulation of the head/bonnet impact (right).



5 WHAT SKILLS ARE NEEDED TO CROSS A ROAD?

By Marie-Axelle Granié,
Senior researcher
TS2[1] Department, LMA[2] Laboratory

Moving around on foot and crossing the road are much more complex than it seems at first sight. If we consider crossing a road as a problem-solving situation, a number of cognitive functions and capacities are required to perform the task safely.

A visual search strategy

First, the pedestrian analyses the situation, observes the traffic and conducts a visual search. This requires some understanding of how the road space operates in order to know where to look so the visual search is informative and effective.

The strategy also involves attention, that is to say the ability to focus on important information, even if other, less important, information is more attractive. At the same time, it is necessary to detect crossing sites where there could be visibility difficulties.

This involves analysing the dangers posed by the topography of the road space. It is necessary to identify where visibility is masked by parking and the road scene must also be perceived from the spatial position of other road users.

In an environment that moves

Pedestrians must obviously take into account the dynamic elements in the road environment, particularly vehicles which are moving or may potentially do so.

Deciding whether a vehicle is moving and determining its direction uses the ability to locate sounds and coordinate data provided by hearing and sight. If the vehicle is approaching, it is necessary to determine how much time is left before contact, i.e. how long it will take it to reach the point where the pedestrian will be at that time. This involves comparing the time that is available to cross the road with the time required to do it.

The second quantity depends on the width of the road which pedestrians estimate on the basis of visual information and their individual characteristics. They must have an accurate idea of their usual speed (which varies with age) and what can affect it (heavy and cumbersome parcels, pushchairs, small children, etc.).

Requiring complex and rapid decision-making

Pedestrians also need to predict what vehicles will do, i.e. anticipate driver's behaviour (is the vehicle going to slow down, continue straight ahead or turn?). This involves taking account of all the factors that indicate or provide a way of understanding the intentions of other road users (indicators, position on the carriageway, road design, the state of traffic, normal driver behaviours, etc.). These factors inform pedestrians about how the situation will change in the future and enable them to decide on their behaviour.

Pedestrians usually have to cope with traffic coming from several directions – at least two. Information must be collected and judgements and/or predictions made based on it for each of these directions. This process requires the short-term memory and the ability to divide one's attention. Next, the information must be rapidly coordinated, in real time, in order to react to the changing situation on the road.

Very importantly, all these skills vary according to the pedestrian's age and experience. They are not all mobilised in the same way in all situations: crossing a road with a pedestrian traffic signal is less complex than crossing a road without one, except if the pedestrian decides not to wait for the green light. But that's another story...

1. TS2: Transport, health, safety Department
2. LMA: Laboratory of Accident Mechanism Analysis

Further readings

Granié, M.-A. (2004). L'éducation routière chez l'enfant: évaluations d'actions éducatives. Apports de la recherche en psychologie du développement à la compréhension de l'enfant en sécurité routière. Rapport INRETS nº 254. Arcueil: Les collections de l'INRETS.
Granié, M.-A. (2010). Socialisation au risque et construction sociale des comportements de l'enfant piéton: éléments de réflexion pour l'éducation routière. Enfances, Familles, Générations, 12, 88-110.
Granié, M.-A., & Espiau, G. (2010). Étude qualitative du comportement piéton de collégiens par la méthode de l'autoconfrontation. Territoires en Mouvement. Revue de Géographie et d'Aménagement, 2008(1), 39-57.
Granié, M.-A., Pannetier, M., & Guého, L. (2013). Developing a self-reporting method to measure pedestrian behaviors at all ages. Accident Analysis & Prevention, 50, 830-839.

6 IMPROVING THE DETECTION OF VULNERABLE USERS BY MOTORISTS

By Joceline Rogé,
Researcher in cognitive psychology
TS2[1] Department, LESCOT[2] Laboratory

Vulnerable road users account for half the world's road fatalities: 23% are motorcyclists, 22% are pedestrians and 5% are cyclists (World Health Organization, 2013). In France, the number of fatalities for each category of vulnerable user are similar to these figures: 24% are powered two- or three-wheelers, 12% are pedestrians and 4% are cyclists (data from 2010). These users therefore represent a major concern for road safety. Studies from a number of countries lead to the conclusion that senior drivers are more involved in collisions with vulnerable road users.

Visual attentional capacities partly to blame

The fact that senior drivers detect vulnerable road users late could it be explained by a malfunction in their information processing sequence. A vulnerable road user first appears in the person's peripheral visual field and a saccade of the eye is necessary to identify them. Perhaps, therefore, the ability to identify a vulnerable road user depends at least partly on the attentional capacity of motorists when they must perceive information in their peripheral visual field. One way of assessing this is to evaluate the size of an individual'susual field of view during driving. This is the surface area around the fixation point in which a person is able to process information while performing a dual task involving the central and peripheral parts of their visual field. During simulated car driving, it is possible to measure this field. Investigation has shown that its size is not constant and it can vary on the basis of the characteristics of the driving task and between individuals. For example, as drivers age the usual field of view deteriorates and a form of tunnel vision develops when driving (Rogé, 2009).

The technique for improving visual attentional capacities on a driving simulator

A training method which improves drivers' usual field of view could have a positive effect on the detection of vulnerable road users in the road environment.

Specific training conducted on a driving simulator led to a considerable improvement in the usual field of view for a group of elderly drivers (with an average age of 70 years). Both before and after the training process, the capacity of the seniors in question to detect vulnerable road users (pedestrians and powered two-wheelers) was measured during a simulated driving task (image on the left). The proposed training was beneficial as it enabled the subjects to detect pedestrians in the road environment more easily (image on the right). The visibility distance for pedestrians (children, adults or immobile or moving elderly persons) was substantially better after training.

The outlook for future research using this training technique

Other experiments need to be conducted to improve our understanding of the effects of training on the visual attentional capacities of drivers. We need to determine the optimum duration of training in order to obtain the maximum improvement in the visibility of vulnerable road users. It would also be interesting to see how long the improvement of theusual field of view remains after the end of training. Finally, we need to test whether the improvement in the pedestrian visibility distance also occurs in a natural environment.

Transport and mobility

▼ The LEPSIS driving simulator (on the left) and an example of pedestrian to be detected during simulated driving (on the right).

1. TS2: Transport, health, safety Department
2. LESCOT: Laboratory Ergonomics and Cognitive Sciences applied to Transport

Further readings

Rogé J., Ndiaye D. and Vienne F. (2014) Useful visual field training: a way to improve elderly car drivers' ability to detect vulnerable road users, Transportation Research part F: Traffic Psychology and Behaviour, 26, 246-257.
Rogé, J. Pébayle, T. (2009) Deterioration of the useful visual field with ageing during simulated driving in traffic and its possible consequences for road safety, Safety Science, 47, 1271-1276.
World Health Organization, 2013. Global status report on road safety 2013, supporting a decade of action, WHO, Department of violence and injury prevention and disability, Geneva, Switzerland, p. 318.

Credit: Ifsttar

Transport and mobility

7 IDENTIFYING BARRIERS TO TRANSPORT ACCESSIBILITY FOR PEDESTRIANS OF REDUCED MOBILITY

By Claude Marin-Lamellet,
Researcher in physical ergonomics
TS2[1] Department, LESCOT[2] Laboratory

Walking is essential in order to use a public transport network. For certain so-called vulnerable users, for example seniors or persons with functional limitations, walking produces disabling situations and the risk of an accident. In addition, changes that are taking place in the urban environment are creating new hazardous situations:

- **Areas with mixed traffic (HGVs and public transport vehicles);**
- **Areas where pedestrians are mixed with cyclists and in-line skaters with no physical separation;**
- **Meeting areas;**
- **Low-noise vehicles (hybrid and electric).**

Trips made more difficult according to the individual's profile

Age-related changes in perceptive cognitive capacities tend to increase the risk of either an impact with a vehicle or falling. The ability to perceive vehicles when crossing the road can also be reduced by hearing impairment. Moreover, seniors have difficulty crossing major roads because pedestrian green times are too short. The reason for this is that they do not take into account age-related reductions in motor capacities which reduce walking speed (0.9 m/sec instead of 1.2 m/s). In this case, and in order to limit fatigue, pedestrians may decide to cross the road before a pedestrian crossing.

Likewise, blind or visually-impaired pedestrians may face difficulties due to the excessive number of obstacles on the footpaths – particularly parked two-wheelers – and the increasing complexity of some road layouts (multiple two-way traffic channels). Last, an important factor is that children with functional limitations like vision, hearing or cognition are at greater risk of injury than children of the same age without these limitations.

Road condition is also an important factor for the risk of falls, particularly in the case of senior pedestrians. Urban planners should therefore give careful attention to abrupt changes from one type of surface to another, which should be avoided, the slipperiness of materials and the identifiability of street furniture.

More appropriate transport conditions

In the case of public transport, the boarding/alighting movement is particularly hazardous for persons of reduced mobility. Low-floor buses reduce this problem, but only if the vehicle is correctly located in the bus berth, which is not always the case. Trams pose fewer difficulties in this respect because of the short distance between the platform and the step.

Travellers with reduced mobility are also vulnerable when making a standing up or sitting down movement. Questions are raised concerning the best way to ensure their safety in the event of sudden braking, as most injuries are not due to collisions but to unexpected deceleration. The principal injury mechanism is falling. Last, the feeling of insecurity, which is subjective and very closely linked to society, is a considerable problem among seniors.

> **"Road condition is also an important factor for the risk of falls, particularly in the case of senior pedestrians."**

1. TS2: Transport, health, safety Department
2. LESCOT: Laboratory Ergonomics and Cognitive Sciences applied to Transport

Further readings

Simoes, A., Marin-Lamellet, C. (2002) Road users who are elderly: drivers and pedestrians; in Human factors for the highway engineer, Fuller.R. & Santos.J.A. eds, Elsevier Science Ltd, Oxford, UK, pp. 255-275.
Marin-Lamellet, C. (2005) Rendre les transports accessibles: Évolutions et problématiques actuelles. Actes des entretiens de la Fondation Garches, Handicap et Environnement: de l'adaptation du logement à l'accessibilité de la cité ; coordination J-F Ravaud et F. Lofaso, Edition Frison Roche, pp. 95-105.
Marin-Lamellet, C. (2009). Mobilité pour tous: des aménagements adaptés aux personnes aveugles ou malvoyantes et aux séniors- Parole de chercheurs, Vol II. INRETS (Ed). Les collections de l'INRETS, pp. 55-58.
Heyrman, E. and Marin-Lamellet, C. (2009). Quelles politiques d'accessibilité au transport en Europe ? Les Cahiers de l'Institut d'Aménagement et d'Urbanisme Ile-de-France nº 150, pp. 112-113.
Grange-Faivre, C. & Marin-Lamellet, C. (2010) Accessibilité des personnes à mobilité réduite et transports guidés urbains/régionaux. In: Innovations dans les transports urbains guidés et régionaux, Claude Soulas et Martine Wahl Eds, Collection Traité IC2 Série Systèmes Automatisés, Hermès, pp. 280-290.

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8 UNDERSTANDING AND IMPROVING THE STREET CROSSING DECISIONS OF ELDERLY PEDESTRIANS

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The elderly people form a particularly overrepresented group in pedestrian accidents in many European countries. In France, in 2012 persons aged over 75 years accounted for 41.1% of pedestrian fatalities, while they make up only about 9% of the country's population (ONISR, 2012). This age group also accounts for more than 20% of those with injuries requiring hospitalisation, i.e. 805 persons in France in 2012. While accidents often have fatal consequences for an elderly person, they can also have severe nonfatal consequences, sometimes leading to a total loss of autonomy.
In spite of the importance of the topic for road safety, the literature contains little research that specifically investigates the decisions and behaviours of elderly pedestrians. Progress in this area has only been made in the last 20 years.

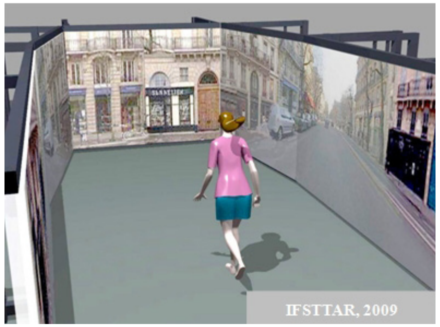
What difficulties are involved in crossing a road?

To understand why elderly pedestrians are often involved in accidents, research has been conducted in situations where pedestrians receive no assistance (for example where there are no pedestrian traffic signals) and where they can make the decision on their own to cross the road. These studies show that individuals of over 75 years of age often select time intervals that are too short considering their slow walking speed. This has been observed on simulators (Dommes & Cavallo, 2011; Lobjois & Cavallo, 2007, 2009; Oxley *et al.*, 2005), on videos of real traffic (Holland & Hill, 2010), and in observations of real situations (Oxley *et al.*, 1997).
This work reveals that elderly persons are slower to make decisions and take the first step, walk more slowly, have diminished abilities to accelerate, and, above all, difficulties perceiving the speed of approaching vehicles or assembling the information from two traffic lanes (Dommes *et al.*, 2014). Generally, the increasing danger faced by elderly pedestrians is interpreted as resulting from the decline in certain capacities that occurs with normal ageing rather than the age of the pedestrian as such (Dommes *et al.*, 2013; Holland & Hill, 2010; Lobjois & Cavallo, 2007, 2009; Oxley *et al.*, 1997, 2005). Such decline affects visual acuity, perception (effective visual field), cognitive activities (attentional capacities), and motor activities (walking speed).

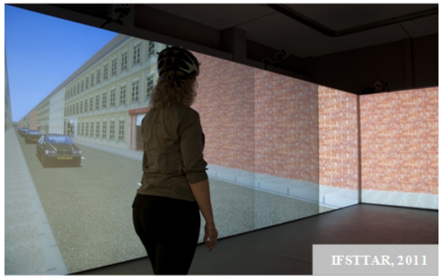
How can decision-making be improved?

One way of improving safety is to make elderly persons better able to cope with the infrastructure and tasks by learning or re-learning safe behaviours. The development of training programs that are specifically targeted at elderly pedestrians would be an effective way of improving safety for this group of vulnerable road users.

Studies conducted at IFSTTAR (Dommes *et al.*, 2012; Dommes & Cavallo, 2012) are, to our knowledge, the first to have tackled this question. The results from simulator tests of a number of training programmes are very promising.



◀ The street crossing simulator developed by IFSTTAR



UNDERSTANDING AND IMPROVING THE STREET CROSSING DECISIONS OF ELDERLY PEDESTRIANS (END)

"The results from simulator tests of a number of training programmes are very promising."

They show that elderly persons' decisions and behaviours can be made significantly safer by a combination of individualised behavioural and educational interventions. The programmes in question present a variety of exercises of increasing difficulty and give the subjects feedback about their errors which improves their motivation and involvement throughout the intervention.

Virtual reality, an effective technique for studying and improving behaviours

Methodological difficulties related to studying road crossing in real situations have restricted the analysis of risk factors and causal factors for accidents. An accident analysis has been carried out (Fontaine & Goulet, 1997), typical scenarios have been identified (Brenac *et al.*, 2003), but some questions remain unanswered. Advances in simulation have increased our knowledge in this area and its applications, and will continue to do so in the future.

IFSTTAR (LEPSIS) is currently the only institute in the world to possess a road crossing simulator in which the pedestrian really moves over a distance of more than 7 metres. The subject is fitted with movement sensors that allow their position in virtual space to be identified and to adapt the visual scenes projected on 10 large screens to the subject's movement and point of view which change when they walk.

1. COSYS: Components and systems Department
2. LEPSIS: Laboratory for road Operations, Perception, Simulators and Simulations

Further readings

Brenac, T., Nachtergaële, C., & Reigner, H. (2003). Scénarios types d'accidents impliquant des piétons et éléments pour leur prévention. Rapport nº 256. Arcueil: Les collections de l'INRETS.

Dommes, A., & Cavallo, V. (2011). The role of perceptual, cognitive, and motor abilities in street-crossing decisions of young and older pedestrians. Ophthalmic and Physiological Optics, 31, 292-301.

Dommes, A., & Cavallo, V. (2012). Can simulator-based training improve street-crossing safety for older pedestrians? Transportation Research Part F: Traffic Psychology and Behaviour, 15, 206-218.

Dommes, A., Cavallo, V., & Oxley, J.A. (2013). Functional declines as predictors of risky street-crossing decisions in older pedestrians. Accident Analysis and Prevention, 59, 135-143.

Dommes, A., Cavallo, V., Vienne, F., & Aillerie, I. (2012). Age-related differences in street-crossing safety before and after training of older pedestrians. Accident Analysis and Prevention, 44, 42-47.

Dommes, A., Cavallo, V., Dubuisson, J.B., Tournier, I., & Vienne, F. (2014). Crossing a two-way street: comparison of young and old pedestrians. Journal of Safety Research, 50, 27-34.

Fontaine, H., & Gourlet, Y. (1997). Fatal pedestrian accident in France: a typological analysis. Accident Analysis and Prevention, 29, 303-312.

Holland, C., & Hill, R. (2010). Gender differences in factors predicting unsafe crossing decisions in adult pedestrians across the lifespan: a simulation study. Accident Analysis & Prevention, 42, 1097-1106.

Lobjois, R., & Cavallo, V. (2007). Age-related differences in street-crossing decisions: The effects of vehicle speed and time constraints on gap selection in an estimation task. Accident Analysis & Prevention, 39, 934-943.

Lobjois, R., & Cavallo, V. (2009). The effects of aging on street-crossing behavior: from estimation to actual crossing. Accident Analysis & Prevention, 41, 259-267.

Observatoire National Interministériel de Sécurité Routiere (ONISR) (2012). La sécurité routière en France. Bilan de l'année 2012. La documentation Française, Paris.

Oxley, J.A., Fildes, B.N., Ihsen, E., Charlton, J.L., & Day, R.H. (1997). Differences in traffic judgements between young and old adult pedestrians. Accident Analysis & Prevention, 29, 839-847.

Oxley, J.A., Ihsen, E., Fildes, B.N., Charlton, J.L., & Day, R.H. (2005). Crossing roads safely: An experimental study of age differences in gap selection by pedestrians. Accident Analysis & Prevention, 37, 962-971.

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