Traffic psychology : mechanism of traffic accidents and deterrent measures

Traffic Psychology

—Mechanism of Traffic Accidents and Deterrent Measures—[1]

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1. Introduction

1–1. General view of traffic psychology

At present, a variety of methods of transportation are in use all over the world and transport is one of the most important foundations of our civilisation. On the other hand, transport produces various kinds of social problems, such as accidents and pollution, with their nature and degree differing by country or region. Traffic involves every kind of vehicle: aeroplanes, ships, railways, passenger cars, buses, trucks, and motorbikes. In this chapter the focus is on road traffic and particularly traffic accidents. Most people have at least some relationship with road traffic and its related phenomenon has social significance. People want their driving to be safer and more comfortable, traffic flow to be smoother, and the cost to be lower.

If people's happiness or human rights, viewed in their deepest sense, are considered seriously, then traffic safety should be the first and main theme of the many problems to be dealt with. That is to say, no one should be killed or injured by traffic accidents. As shown in statistical data, the phenomenon of accidents is rather stable and incidence in a period can be roughly predicted. Thus traffic accidents are not just 'accidents' in a strict sense, but should rather be regarded as social phenomena which originate in the characteristics of the road traffic system. This point is easily understood when you compare road traffic accidents with aeroplane accidents. The number of people killed in aeroplane accidents is more difficult to predict than that of road traffic. The causes of aeroplane trouble or accident have been rigorously investigated and controlled technologically. Furthermore, the weight of the human factor in piloting an aeroplane can be regarded as smaller than that of driving a vehicle on a road. Therefore aeroplane accidents can be said to be caused by unknown processes. That is a real accident. On the other hand, that is not the case for road traffic accidents. Why do a stable number of accidents happen every year? The causes supposedly arise mainly from human factors which are not easy to control. Are they all really impossible to be

1 This paper is an English translation of 'Taniguchi, S. 2005 Tam ly hoc giao thong: Co che cua tai nan giao thong va cac giai phap phong ngua. In Vu. D., Ito, T., Phan, T. M. H. and Yamamoto, T. (eds) Ung Dung Tam Ly Hoc tai Nhat Ban (Applications of Psychology in Japan) Hanoi: Nha Xuat Ban Tu Dien Bach Khoa (Hanoi: Encyclopedia Publishing House), 169–213. (in Vietnamese)'.

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controlled?

Research on traffic behaviour constitutes an important area of Applied Psychology. There are some research organisations or associations which deal with traffic accidents. In the psychological fields, the international one is IAAP (International Association of Applied Psychology) and it has a special division of Traffic and Transportation Psychology. In Japan, JATP (Japanese Association of Traffic Psychology) is the representative and JAAP (Japanese Association of Applied Psychology) has a traffic section at its annual conference. In Europe, some associations can also be noted, such as ICTCT (International Co-operation on Theories and Concepts in Traffic Safety), and conferences such as ICTTP (International Conference on Traffic and Transport Psychology). There are also some research associations outside the field of Psychology.

As with psychology in general, Traffic Psychology has three purposes. The first is to describe phenomena, the second to explain mechanisms, and the last to predict and prevent accidents. As in other areas of Applied Psychology, Traffic Psychology research has numerous difficulties, as phenomena arise from many and complex factors and are not easily controlled or anticipated. We need experimental approaches to refine the mechanism of selected factors. The results obtained from experiments are important in enabling the understanding of actual behaviour, and so both experimental and field approaches have a role in research. We have to determine advantages and disadvantages.

1–2. Road, Traffic, Information System, and Car Engineering

Table 1 shows some disciplines of Engineering and their representative research themes which concerns car traffic. Driving is an interactive process among a driver, a car and a road environment. The physical features of a car and a road environment have strong effect in determining driving behaviour. For example, speed depends on performance of a car, collision risk is reduced if a car is equipped with a headway warning system, and traffic lights at an intersection improve flow and safe crossing remarkably. Therefore putting infrastructural and traffic environment in good condition and developing a safer car should be considered important as well as education. However, one point of view should be reminded that some kinds of safe systems (would they be of a road or a car) could induce riskier behaviour than before, i.e., which surpass the supposed effect of the system. Or it could be in some cases that a safe system makes a driver's ability of hazard perception lower.

A new technology which is expected to contribute both to research and pragmatic use is noteworthy to refer here. That is 'Drive recorder' which basic idea is similar to the well known 'Flight recorder' equipped in an airplane. The flight recorder gives inevitable data in case of accident to analyze the causes. The drive recorder can be utilised in the same way, however it is useful for more various purposes in ordinary situations besides an accident. The recorded items are, for example, speeds, braking, handling and the position of a car measured by GPS (Global Positioning System). Those are recorded for a given period. If the recorder is only for an accident, unnecessary data during safe driving is abandoned after a period, the data around an accident is preserved and the equipment finishes recording new data. At present, the number of cars which

Table 1 Some Research Themes of Road, Traffic, Information Systems, and Car Engineering

Road Engineering
Geometric design
Bridge, Tunnel
Intersection
Traffic sign, indication
Road lighting
Traffic lights
Pavement
Crash barrier
Traffic Engineering
Traffic planning
Traffic demand management
Traffic lights management
Traffic congestion measure
Traffic safety management
Traffic control
Information Systems Engineering
VICS: Vehicle Information and Control System
ITS: Intelligent Transport System
UTMS: Universal Traffic Management System
Car Engineering
ABS: Antilock Braking System
ISA: Intelligent Speed Adaptation
ASV: Advance Safety Vehicle

have the apparatus is not large and the actual data can not be obtained from all the cars which are involved in an accident. When the recorder is spread to a majority of cars, the process of a collision could be clarified much easier by the data from all the cars. The data of daily driving could provide a guide to risk level of a driver's behaviour. The new type of insurance contract based on the information could be possible as special reduction for lower level of average speed. Therefore the drive recorder is promising for both the research of traffic accident and the pragmatic tools to facilitate safe driving.

1–3. Statistics of traffic accidents

Traffic accidents are defined as a process or a result by which pedestrians, cyclists, and/or cars are in collision or other impact with each other, leading to some damage to objects or persons. Dangerous driving or behaviour means those human behaviours which have not actually resulted in an accident but will certainly do so under certain environmental conditions.

Figure 1 shows the statistics of road traffic accidents in Japan. The worst was recorded in 1970, when 16,765 people died (within 24 hours after an accident) in a year; also the worst with regard to the rate per 100 thousand, 16.2 people. In 1979, fatalities dropped to 8466 and after that the number began to increase slowly to 11,451 in 1992. In 2001, fatalities have dropped to less than 9000. However, the number of accidents has risen steadily up to the present.

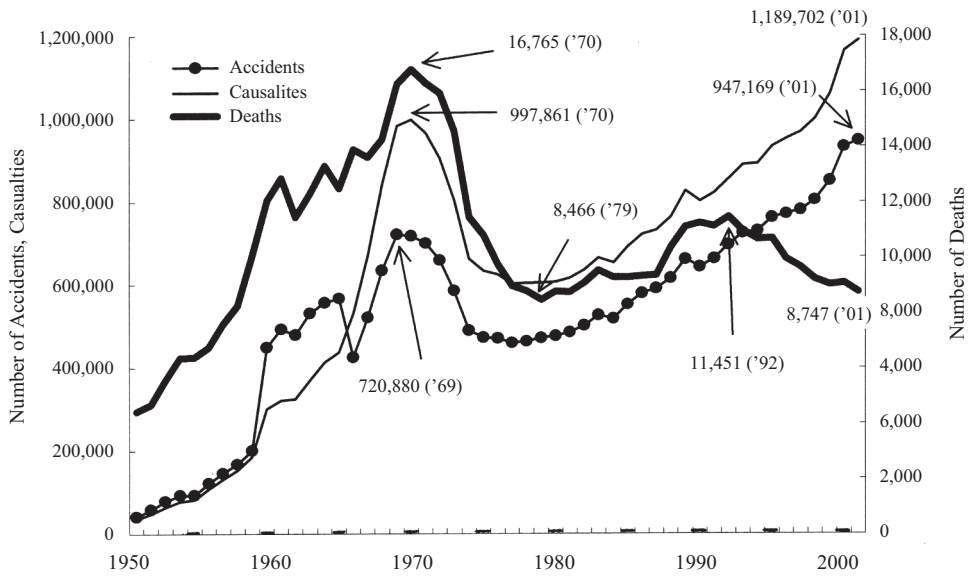

Figure 1 The change of the number of traffic accidents, casualties and deaths (Management and Coordination Agency of Japan 2002 Traffic Safety White Paper in 2002)

Note 1 The data is from Japan Police Agency.
Note 2 Non injured and death accidents are not included in and after 1966.
Note 3 Okinawa prefecture is not included until 1971.

Table 2 reveals comparisons with other countries. It is not easy to establish a strict definition of 'Fatal accident rate'. One index is tentatively calculated in the table. This means the number killed, by the number of cars owned. Some differences can be found among the countries. Distinctly, those of Korea and China which far exceed those of other countries.

Here is one example of comparison in some detail of two countries, Sweden and Japan, regarding the characteristics of traffic accidents. There are some differences between the traffic environments of the two countries. The main reason for the difference could be found in the difference in traffic density. The population of Sweden was 8,848 thousand, the number of vehicles in use 4,040 thousand (one for 2.19 persons) in 1998. The number of people injured in traffic accidents in the year was 21,356 and those killed was 531, 6.00 per 100 thousand. On the other hand, the Japanese population was 126,486 thousand, the number of vehicles registered 68,634 thousand (one for 1.84 persons) in 1998. The number of people injured in traffic accidents in the year was 989,081 and those killed within 30 days after an accident was 10,805 (Management and Coordination Agency of Japan, 2002). Therefore, the calculated death rate per 100 thousands was 8.54. The largest difference between the two countries as a factor influencing traffic environment was the population density. The land area of Sweden is about 19% larger than that of Japan. The population density of Japan is 16.9 times as large as that of Sweden comparing simple ratios of total size of the countries and populations. However, it should be a little smaller if it is calculated excluding uninhabited areas.

Table 2 Comparisons of fatalities on road traffic accidents with other countries (Management and Coordination Agency of Japan 1997, Traffic Safety White Paper in 1997)

Indices	USA	Australia	Germany	England	Korea	China	Japan
Number of Deaths	41,798	2,017	9,454	3,621	10,323	71,494	12,670
Population (thousands)	262,755	18,049	81,539	56,800	44,800	1,181,820	125,570
Number of Cars (thousands)	196,583	10,638	45,200	24,775	7,469	10,400	69,291
Population / Car	1.34	1.70	1.80	2.29	6.00	113.64	1.81
Deaths / Cars (10 thousands)	2.13	1.90	2.09	1.46	13.82	68.74	1.83

As noted above, the most basic difference between the two countries is density of population and traffic. The general impression one has of the traffic environment in Sweden after actual driving is that there are only a few cars, no terrible traffic jams, wide and straight roads, and distinct borders between rural and urban areas. The Japanese traffic environment is the opposite. With regards to speed, rural roads in Sweden are almost like expressways, with their speed limits being the same as those in Japan; apparently it is natural for people to travel at such high speeds. The ratio of the number of people killed to the number of injured is 2.49% in Sweden and 1.09% in Japan. On the other hand, the proportion of people killed inside a vehicle is higher in Sweden (61.6%) than in Japan (27.6%). This could imply that there are more accidents at high speeds in Sweden, for there seems to be no other cause than that of speed which might lead to drivers or passengers dying inside cars. It is also assumed that the standards for evaluating injury accidents are equal for both Japan and Sweden. However it cannot be confirmed, for statistics regarding estimated speeds, just before accidents are not available.

2. Mechanism of Traffic Accidents

2–1. Determinants of traffic accidents

Psychological mechanisms of traffic accidents can be understood by the well known basic scheme.

$$B = f(P, E)$$

The equation means human behaviour is decided basically by two factors; one factor is the environment around the person behaving, and the other is internal to the person. An accident happens as a result of an interaction between these two factors. The purpose of the analysis is to identify the factors which exist in the environment and the person (factor analysis), and clarify how they work in a given condition (condition analysis). Consequently, the final purpose is to construct the model of the mechanism.

2–2. Characteristics of visual perception

The most important information necessary for driving is provided by vision. Some kinds of perceptual traits or limitations of visual function could produce incorrect or insufficient cognition and then cause maladjusted driving, an accident. A driver gives attention to the surroundings, to seek necessary information in the traffic environment with his eyes moving. That kind of visual attention has limit in its resources, which is measured by range of useful field of view or by detective response time of a target. The performance of peripheral vision decreases in a congested situation (Miura, 1986). The reason is that if more resources are needed to gaze on some objects then the more conjectured the traffic situation is.

There are various visual illusions in traffic environment. The degree of a slope, a radius of a curve, width of a road and a distance between two cars are perceived differently from the correct, physical ones to risky direction under given conditions. Interesting research was reported by Uchida & Katayama (2001) that studied the accidents at cross traffic intersection with clear sight conditions as in the rural districts and the preventive and safe measures against them. They revealed there is collision timing in two cars coming to the intersection and a driver tends to fail in detecting the other car which looks to be standing still. They proposed to install a board beside the road around the intersection, which produces on and off the sight of a car and the other driver can easily notice the movement of the car.

There is a critical defect of vision, that sometimes leads to serious or fatal accident to a pedestrian passing on a zebra zone at night. That is, disappearance of a pedestrian from a driver's sight. This phenomenon is caused by glare from an oncoming vehicle's head lights which results in a pedestrian occasionally vanishing completely. Worse, the person walking between two cars, being lighted distinctly, believes he is surely recognized by the drivers and won't confirm the safety. In order to prevent this kind of accident, a driver has to be educated about the knowledge of the phenomenon and when he comes to that kind of situation, he should slow down or better to almost stop his car before crossing the zebra and to reconfirm if there are any pedestrians passing. It is recommended to move a driver's head a few times right in order to make detection easier.

Subjective speedometer is affected mainly by visual stimulus although auditory stimulus has a little effect on it as well, and the subjective speed is lower than the objective one in general. The difference between subjective and objective speed emerges when the speed of a car changes, for example from an ordinary road to an expressway or the reverse. In the former case, the subjective speed is higher, and it is not so risky. However in the latter case, when a car has begun to run on an ordinary road after a long trip on an expressway, it is risky that a driver recognizes more than twenty kilometres lower than the real speed. It is considered that the adaptation level of speed feeling is set at higher level while driving on an expressway (Schmidt & Tiffin, 1969).

2–3. Information processing

Understanding the flow of information processing in car driving requires basic knowledge. Visual stimulus is the main information, although other audio and sensual stimuli play minor roles. Light enters the driver's eye, and is focused on the retina, retinal cells produce electrical signals.

They are transmitted to the visual field of the cortex in the occipital region, producing the visual sense of seeing. The process takes around 100 milliseconds after light arrives at the eye. Visual information is then sent to the next step of evaluation. One of the simplest functions of evaluation might be 'something happened'. This takes around 300 milliseconds. The lengths of time mentioned above are based on the knowledge of VEP (Visually evoked potential) or ERP (Event related potential) in the research of the brain in Physiological Psychology. The evaluation process quickly leads to the next step 'you have to brake'. The conclusion is conducted in the motor field of the left hemisphere and the signal is transmitted along the nerve fibres to the leg muscles. The muscles contract to step on the brakes. The mechanical system of the car conveys the force to make the brakes work. This produces friction between the tyres and the road surface. Consequently, the whole process, from the moment an event occurs on a road to the friction, takes around one second. Ordinary people in their daily activity fail to recognise the difference, and instead perceive the event and response simultaneously. This way of cognition seems to be natural and doesn't produce any critical maladjustment in daily life.

2–4. Speed as a determinant

The information process from reception of environmental stimulus to driving action is the sum of nervous, motor, and mechanical systems, and it needs a period of time for processing. However, many drivers fail to be properly aware of the time. Of course, they don't need to recognise it as long as they drive at normal speed. The time aspect strongly relates to speed problems in the mechanism of traffic accidents. If a driver has enough time to process the stimulus and drive the car properly at a relatively low speed, there is only a slight possibility of accident. On the other hand, at a higher relative speed, it is likely a driver will not have sufficient time to respond safely to a change of environment. Thus sufficient time to drive properly is a necessary condition for safe driving, and adequate speed, that is, relatively low speed, is needed. The relation between the time (t), distance (d) and velocity (v) is simply described in the following equation. A faster speed yields less time for coping with an event.

$$t = \frac{d}{v}$$

As an instinctive mechanism, human beings have some kind of system to avoid risky situations or to maintain safety. For example, we feel fearful when we stand at the top of a precipice. The mechanism originates from prehistory. Regarding speed, we cannot run faster than thirty-six kilometres per hour, which is the fastest speed of professional sprinters. We can recognise speed accurately feeling wind and body vibration, and we can manage to change direction or to stop properly as intended. However, the history of car is less than fifty years for the majority of people and it is too short an experience for them to obtain a biological mechanism to deal with its speed safely, if it is even possible. Thus people fail to recognise the risks of excessive speed. Moreover, the better road conditions become and the more comfortable cars become, the more difficult it becomes to sense the risk of speed.

2–5. Accident propensity, personality

There are some personality traits which are apt to produce traffic accidents. They are a) emotional instability or neuroticism, b) aggression or sensation-seeking and c) lack of social co-operation; they have been identified in many research surveys using MMPI, YG-test, PF-study, and Rorschach test, etc. However, the relationship between those traits and traffic accidents is not so clear. As many surveys show, the difference of traits between accident and non-accident groups is not large, although it shows statistically significant difference. These traits must not be understood as suggesting that 'those people who have the traits' should cause accidents, but that 'these psychological conditions' could cause accidents. Therefore, even if a driver has a propensity for accident, he will not necessarily cause an accident unless the trait occupies him at the critical moment; on the other hand, a driver who doesn't have the trait could cause an accident if his psychological condition is under control of the trait.

Other factors in both a driver and a road are related in deciding if an actual accident occurs or not. An accident should occur when actual hazard conditions are supplied as two cars come across physically and a driver could not notice it or evade the collision by adequate drive operation. A driver doesn't experience such a critical situation frequently, for the probability in which the situation occurs is far lower than that of non hazardous situations. However, the number of hazards actually experienced increase directly, corresponding time and distance of driving. Concerning driver factors, each skill level of risk or hazard perception, and motor action of operating a handle or an accelerator, decides the result of safe passing or an accident. Accident propensity on personality could exist at fundamental level to decide general direction of behaviour which has weak correlation to traffic or driving behaviour. One of the more focused on driving behaviour is the driving attitude scale which includes questionnaire statements describing various traffic situations to discriminate those who are predicted to experience accidents in high probability, from those who are not (e.g., Fujimoto and Azuma, 1996). The other is the aptitude test of driving, which measures perceptual and motor skills besides verbal responses by questionnaire to find out neurophysiologic defects. A small number of people seem to have an innate disorder of important abilities, necessary for safe driving. They cause accidents frequently and it is very difficult to modify their risky behaviour to a safer one.

2–6. Factors of sex and age

Sexual differences on traffic behaviour or traffic accidents are known to exist. They are presumed to originate from instinctive properties of sexuality. Taking an example from one of the main personality traits of aggression-cooperation, the female is less aggressive and more cooperative than the male in general. This is also consistent with traffic behaviour. Women's slow, moderate and gentle style of driving, in contrast with men's quick, vigorous and aggressive style. Concerning the age, younger drivers' behaviour is similar to that of the male and the elderly to that of the female. How about the probability of traffic accidents? It is not the stage for us to reach the conclusion but it is known that the typology of accidents of male and female drivers is different. Accidents due to speeding and drinking are more observed in the male and the accidents which result from defect in

perception and operating skills are many in the female.

2–7. Risk Compensation

People sometimes showed more risk-taking behaviour prior to any kind of safety system being introduced. In the earlier days when ABS or SRS (airbag) was started being equipped to cars by option, it was found that accident rates of cars with those safety equipment were higher than those without them. Those who used the equipment drove their cars in a more risky way, i.e., excessive speed and forcible passage. People have 'target risk' which is the level of risk a person chooses to accept in order to maximize the overall expected benefit from an activity. He is inclined to maintain the degree of risk-taking behaviour and the magnitude of loss due to accidents over time, unless the target level of risk is changed, i.e., risk homeostasis (Wilde, 1994). This phenomenon has important implications that one has to be careful of when a new safety system or equipment is expected to be implemented. The new traffic environment, or a car which is supposed to enhance safety could promote unintended riskier behaviour than before.

2–8. Environmental factors

Human behaviour occurs within an environment. A person has a physical body and his activity is basically and strongly regulated by the properties of the physical environment in which he lives. Regarding driving behaviour, proper driving involves avoiding an error in information processing to collide with or scrape other objects. But it is wrong to say that safety relies exclusively on his attention or operation. In the first place, more than anything else, the physical environment should be safe, and correct information about it should be accessible to a driver. This means that the road and car should not have any deficiencies; they have to work well, and the driver has to sense, perceive, and recognise these physical stimuli correctly. As a matter of course, education should be another fundamental and should not be treated lightly; the other aspect is to ensure that the traffic environment is right and safe. This is the starting point for everything. Some concrete suggestions for this will now be introduced. The basic point in conducting research or practical measures is that the relationship between the physical environment and a person is never neglected. That is how the stimulus is received, processed in a person and finally leads to behaviour.

2–9. Road environment

A road environment is mainly dependent on its physical properties: ordinary road or motorway, lines, curves, slopes, tunnels, traffic lights, traffic signs, information, and the number of cars around or driving conditions, etc. From a wide perspective, natural conditions such as weather or time of day should be considered. These conditions determine how each stimulus reaches a driver, and occasionally causes information processing errors.

2–10. Special characteristics of the environment inside a car

A driver in his seat is under the control of a special environment. A driver can operate a relatively big car, twenty times his weight, simply by using his arms and legs with slight effort, and the space

inside a car is small, but is almost completely occupied by the driver. Moreover, a driver knows very well that it is difficult for other persons around the car to identify him, even though the car has a number plate. Thus he feels rather free, knowing he is not responsible for any problems which accidentally happen. His face is not easily seen from outside because of the reflection of the windows or windscreen, and the car doesn't stay in one place and can easily move away. These features of the space inside a car make up its special characteristics. It is very natural that driving behaviour under these circumstances is very different from those of the environments of ordinary life. One typical kind of behaviour under these conditions is aggressive driving. In an everyday environment, people have contact with others face-to-face, or by telephone, knowing very well who is who. Aggression is strongly suppressed in such situations. However the suppressive function seems to weaken under conditions of anonymity.

2–11. Car performance

Human behaviour is generally decided by the relationship between internal factors (drives) and external factor (incentives). It is the same for driving behaviour: how you drive a car (drive) is decided by your relationship with the performance of the car (incentive). For example, the drive to go fast is easily satisfied if the car has that level of speed performance. Conversely, you can't drive fast if your car doesn't have that level of speed performance. On the other hand, a car has other aspects such as supplementary functions for information processing and operation. Blind corner monitors, near-miss warnings, doze warnings, are examples of the former. Brake assist, ABS (Anti-lock Braking System), VSC (Vehicle Stability Control) are the latter. GOA (Global Outstanding Assessment, there are other names for a similar system.) Body and SRS (Supplemental Restraint System, airbag) are safety systems to protect persons in accidents. Those supplementary functions and safety systems are not only a matter of engineering but they also have important effects on drivers' behaviour as described in 'Introduction' or in 'Risk Compensation', etc.

3. Education and Reinforcement

3–1. Necessity of education

Safe driving tends to reduce over time, as there is a basic tendency of drivers to reduce energy used to maintain safe driving, or to fail to recognise the possibility of danger. On the other hand, they want more direct benefits from driving, such as speed or excitement. In general, there needs to be an innate or acquired mechanism for behaviour to occur. The behaviour should be maintained and occur repeatedly through the reinforcement of reward for the behaviour. The reinforcement of ordinary driving would be accidents (negative reinforcement) or safety (positive reinforcement). Here the probability of safety is very high compared with that of accident, which is extremely rare. In many cases, safe driving requires a reduction in speed and stopping many times to ascertain safety. These use energy and are not pleasurable. However, the opposite type of driving produces more direct pleasure and a lower cost, at least intuitively. The result of safety itself is regarded as inevitable, and thus it is hardly recognised positively as reinforcement. You need more ability

to imagine the horrific and shocking scenes of an accident, rather than the really low rate of actual accidents. Cutting costs for safe driving which needs not less energy, and releasing the uncontrollable need for speeding, that is so to say lazy driving, gives a direct feeling of pleasantness which works as reinforcement of behaviour. It still, however, doesn't connect to accidents in the majority of cases, but safety. An accident never happens unless all the conditions are satisfied. It is very rare that an actual accident happens. This is the reason why safe driving is apt to be reduced, and a shift to dangerous driving occurs. Thus education is needed to maintain safe driving behaviour or to reinforce it.

3–2. Educational program and teaching method

The method of conducting education effectively is an important task. Knowledge from cognitive, learning, social, and educational psychology could possibly be utilised in practical educational situations. It is a pity that at the present, much of such knowledge is not being employed. Concrete programmes and techniques are required for effective education, and ought not to be too difficult if proper researchers and the necessary budget were made available. The long term, wide vision of the program is that of life education. What is the objective of education at each developmental stage from infant, elementary to higher education, youth, adult, and the old aged, over the whole course of life. How do they relate to each other? Educational evaluation and maintenance of the acquired level should be clarified as well. There are many problems to be resolved, such as educational materials, equipment, establishment and the total environmental conditions.

In Japan, the official curriculum guidelines for primary, junior high and high school, involve traffic safety in health education and physical education. Hence, there are some educational activities for traffic safety in schools although they are not sufficiently systemised. Their content and the level of accomplishment vary, depending on the persons or organisations in charge of the work. However, the most important education for traffic safety is given at driving schools, which the majority of people who want to get a licence attend. School fees for a standard licence are around US$2400 and the curriculum involves both study (26 hours) and practice (34 hours). It usually takes around one month to complete the course and get a licence.

Furthermore, there are a variety of social activities for traffic safety. As an example of official action, companies which own more than a specified number of cars must, by law employ a company traffic safety officer, who must attend a one-day seminar every year. Every spring and autumn, there are big campaigns at a national level, such as Spring Traffic Safety Week. On the other hand, some journals are issued which include many articles on traffic safety. JAF (Japan Automobile Federation) is the biggest organisation for rescuing disabled cars, and publishes a membership bulletin every month. Signal is the name of a journal which introduces much scientific and practical data for ordinary people to easily understand.

There are various educational methods, but the most common is the lecture about traffic safety. The content can be classified as: importance of safety education, mechanism of traffic accidents, results of traffic accidents, and concrete and detailed techniques to avoid traffic accidents, etc. Sometimes a questionnaire or a self-check list for safe or risky driving can be used in a lecture to

improve attendees' subjective interest in the lecture.

3–3. Hazard perception test

The concept of 'hazard perception' should be discriminated from the similar concept of 'risk perception'. Risk is a little more abstract than hazard, for it regards statistical possibility of traffic accidents, while hazard means actual situation of a driver and an environment which could produce accidents. Therefore risk perception is related to general attitude of driving and hazard to real condition of accident. Mckenna & Crick (1991) devised a hazard perception test using reaction time on hazard situations of driving which was displayed in video image. They found the reaction time of skilled drivers, is faster than that of the novice or the less experienced. Furthermore, they reported performance of the hazard perception test, clearly revealed improvement after lectures and practices using real cars (Crick & Mckenna, 1992; Mckenna & Crick, 1993).

3–4. KM model

KM model (Matsunaga, 1998) is one of the most useful theories on the mechanism of traffic accidents. The model is actually being used in the various fields of driver's safety education. The theory explains that a traffic accident gives rise to a sudden delay in perception, cognition, and motor response, which is found frequently in the drivers who experienced accidents. This sudden delay is thought to originate from physiological processes in the brain, and it seems to be difficult to avoid, even if a driver of such tendency makes efforts. Then, another strategy to make up the defect is needed, that is to keep the headway longer in order to secure enough time to control a car. The safe headway is decided according to the velocity at the moment. A field observation reported the headway, measured in time is around one second in Japanese express way. That level of headway is risky for general response time (between stimulus and tire-road surface friction) and is usually less than one second. A small delay in information processing in detecting an obstacle, should give rise to an accident. The model explains the reason why many people compete with each other and urge each other to go faster than the others in the view point of survival instincts, i.e., for foods. Although the instincts cannot be recognized consciously, it is considered to strongly control such kind of competetive driving. Regarding the coping strategy for the competing mechanism of many drivers, the model proposes a practical educational procedure, which aims to promote drivers' understanding of the latent risk, of the competition or the merit of non-competition, and the rational and intellectual understanding produces actual modification of driving behaviour. An educational video tape based on the model was produced and has been utilized in the driving schools or safety courses. There has been some reported results on the effects of the model based on experimental and field studies.

3–5. Commentary driving method

A driver reports verbally what he watches during driving; characteristics of a road as curve, an intersection, a traffic light and a traffic sign, and behaviour of other road users, e.g., cars, cyclists and pedestrians. Another person as a conductor can understand more objectively what the driver

found and paid his attention to. Cognitive process of perception and feeling on traffic event, can be known from the comments and some problems can be analyzed in terms of risk perception or hazard perception, although the stream of consciousness does not reflect all the information process on driving.

3–6. Simulator

Recent development of personal computers and CG (computer graphics) has facilitated a higher level of driving simulation based on virtual reality technology. The more realistic feeling of driving is produced by sound and gravity feeling, not to mention refined imagery or movement of traffic objects. The merit of simulation is that a driver who is to be educated can practice some safety skills of risk/hazard perception and adequate operations to avoid an accident, without exposing himself to real danger. If the educational item doesn't include a dangerous situation, it is no doubt that practices using a real car would be better. Our task is to discriminate which educational items are more appropriate for the simulator with respect to effectiveness, cost performance, and the assembling of adequate programs.

3–7. Counselling

Counselling is a suitable method to deal with a problem driver who has strong accident proneness or who had an accident actually. A traffic counsellor should have expertise in traffic safety, especially Traffic Psychology and basic counselling techniques. Individual or group counselling is chosen considering the problem to be solved. Some Psychological tests, aptitude tests, and performance tests could be conducted according to the case. Feeding back some of those results of measurement to the subject, the conductor points his problem out and facilitates the subject to understand it and to modify his behaviour in a desirable direction.

3–8. Small group method

The purpose of the group's activity is to improve traffic safety of the members. This method could be utilized in school or workplace. Concrete content of activity would be, for example, learning knowledge of traffic safety, exchanging risky or near accident experiences, case study of an actual accident. Books, videos, aptitude tests, etc. could be used as materials for those activities. A group of less than ten persons is adequate in order for the method to be effective. Five or six seems to be advisable empirically. This method's requirement is that every member should attend the activity positively. In a discussion session, every member is expected to introduce his experience or to express his opinion. If the members are too many, someone may miss the opportunity to speak at all, and if too little, not enough discussion would be expected. Studying new knowledge is not only the purpose of the group but the process of positive discussion or exchanging experiences enhances members' safety attitude and actual behaviour more effectively. In order that every member attends the activity and the activity produces a fruitful result, a leader should be trained sufficiently to get necessary knowledge for management.

3–9. Reinforcement by Police

Punishment with a fine or a point system (each violation of traffic law is given a kind of penalty point which is accumulated to decide a right for driving license or the level of the obligatory course for renewal of licence) by police is very effective. In 2002, the amount of fines and points was amended to be severer with regard to drinking and overworking, etc. For example, drink driving can be sentenced to a maximum of three years' penal servitude or a fine of 500 thousands yen (two years or 100 thousands yen in the old traffic law). The penalty point was modified to 25 points from the old 15 points. Considerable reduction of driving under the influence of liquor is being reported since then.

The common police control is related with speeding, illegal parking, and drink driving. An automatic speed camera is set at a stretch of road where people tend to drive faster than allowed. The camera takes a clear photo of the driver's face and the number plate of the car. The speed threshold over which the camera works is usually set at much higher speed than the legal limit. People suppose it might be around 25 km/h over. Therefore, only the drivers who exceed extraordinarily are picked up. The amount of a fine and penalty points are provided in detail in a list according to the amount of speed exceeded. Speeding over 25 to 30 km/h by an ordinary car costs eighteen thousands yen with three penalty points.

The obligatory course for renewal of licence is conducted by police offices. The duration is thirty minutes for excellent drivers who have no penalty points during the last five years and one hour for those who have less than three penalty points, and two hours for others, so to say the violators, and first renewal drivers. People of more than 70 years have to take a special course for the aged before the renewal. Those courses are considered to be very important occasions for educating drivers to maintain and to improve safe driving and to let drivers know alterations in the traffic laws.

3–10. Safety management at workplace

The Japanese traffic law states that every company which uses more than five cars has to appoint one or some safety managers who work for the traffic safety of the company. Some of their tasks are, planning and support of safe travel driving, checking a driver's health and condition of a car just before departure, taking care of a driving diary, and education and technique for traffic safety. In case a company car had an accident, the manager might be responsible for safety of the travel planning, etc. In order to improve their knowledge on traffic safety, they have to attend to a special course of around five hours once a year.

3–11. Traffic Psychologist

The Japanese Association of Traffic Psychology is an authorizing system for the qualification of Traffic Psychologists, newly established in 2002. The 'Traffic Psychologist' involves some grades to qualify depending upon an applicant's academic background, practical career in activity on traffic safety such as a driving school teacher, a lecturer for traffic safety courses provided by the traffic law or at university, and papers published or presented at academic conferences, etc. For the case an applicant who does not satisfy the requirements, a special seminar is prepared to make up

for this. The qualification will be utilized for the purpose to guarantee the person that he has enough knowledge and teaching technique which is necessary for activity in the field of traffic safety. The Traffic Psychologist could be a kind of required condition for official positions in relation to traffic safety. In Europe, they have a long history on the qualification and the work of a Traffic Psychologist is acknowledged more widely (Chaloupka and Risser, 2002).

4. Necessity of Speed Management

4–1. Speed as a determinant of accidents

Speed is a critical determinant of traffic accidents. It is clear that an object moving at a high speed has a tendency to cause errors in information process. This is because the object is difficult to catch visually and the processing time is apt to be insufficient. The other important point is that the speed of a car, decides the level of damage when an accident happens. The faster a vehicle goes, the more energy it has, and the more serious the damage from a collision. The relation between kinetic energy (E), mass (m) and velocity (v) is clearly described in the following equation from Physics.

$$E = \frac{1}{2} mv^2$$

It is therefore clear, that control of excessive speed can be one effective deterrent against traffic accidents. Traditional measures to suppress speeding, have been in the form of education and police enforcement. They have certainly had some effect on reducing some people's speeding, under some conditions. However the effect is limited. There are some people who usually drive at an excessively high speed and there are also a number of occasions on which momentary high-speed driving is performed by drivers who usually don't drive at such high speeds. Thus, strict control of speed is necessary for those people and occasions.

4–2. Motive, incentive and availability

The psychological mechanism deciding speeding behaviour merits some discussion. This approach should improve understanding of the necessity and effectiveness of the physical control of speed. The mechanism consists of three parts: motive, incentive, and availability of incentive (Taniguchi, 1999).

Motive means the level of speed at which a person chooses to drive. The level of speed is changed by the driving purpose, driver's education, etc. It also differs according to the driver's characteristics. Some characteristics may be biologically based. Typical examples are sex and age which may be related to an instinctive mechanism. This means the motive for speeding is as strong as the drives of appetite and sleep, so that it could be strong enough to control human behaviour.

Incentive is the car itself or the speed performance of the car which could satisfy a person's motive.

Availability is a physical condition in which the motive can be connected with the incentive. Therefore the availability decides finally the possibility of actual speeding behaviour which the motive wants to emerge.

It is rather difficult to control the motive inside a person. Motive is unstable and always fluctuating. There could occasionally be an abrupt explosion of strong need for high speed, no matter what, consciously or unconsciously. On the other hand, incentive can be easily controlled. With regards to speed behaviour, both incentive and availability should be focused on for the purpose of controlling speed behaviour. At this point, prevention of dangerous speed performance by a car could be regarded as relating both to the incentive itself and its availability. Or there could be slight differences between them. The fact that a car has a high-speed performance is recognised by the driver even while the opportunity to employ that performance is temporarily limited. His speeding behaviour is controlled by the limitation of the availability of incentive. The driver could be satisfied by the possibility of going much faster in other conditions. In that sense, the concept of availability should be useful, as something to be differentiated from incentive.

4–3. Aggressive behaviour metaphor, uncontrollable drive

The following is a discussion of aggressive behaviour as a metaphor in order to improve understanding of the mechanism of speeding behaviour. Aggression is a kind of instinctive drive which is biologically necessary for survival. Human beings at present still preserve the drive, although in many cases they are not allowed to express it directly. Thus it must be redirected in other ways such as through sublimation and repression, which were identified by Freud to be parts of the self-defence mechanism. In spite of the mechanism, there are still rare situations in which one is violently aggressive against someone almost dead, although that isn't a common phenomenon for most people or under many conditions. The uncontrollable aggressive drive is considered to correspond to the motive for speeding, and a car with sufficient speed performance, which is enough to satisfy the motive, corresponds to weapons such as knives or guns. The aggression when the latter weapons are utilised is of course different from the motive of speeding in its abruptness, i.e., characteristics of intensity and time duration.

If a murderous weapon is available when a man experiences strong feelings of aggression, he will be sure to use it. The aggressive drive is also accelerated by interaction with the incentive available. Thus the availability of a weapon, is one critical condition that decides whether a severe attack like murder actually occurs or not.

With regard to measures to control a person's behaviour, there are some choices. One is to persuade a person not to take action by talking, or some educational program about ethics or morals could be possible. However, none of these are likely to be effective at all once a similar kind of mechanism to FAP (Fixed Action Pattern), the construct of instinctive mechanism in Ethology, comes into play. Another course is prevention of the use of effective weapons. Deprivation of availability of the weapon will make it impossible for it to be used. The last option left might be his own fists, but that would not yield the same critical effect of killing or hurting another person seriously. There also seems to be a kind of hesitation when one wants to use a body part as a weapon, perhaps due to an aversion to what one imagines violent physical contact will feel like. As the metaphor above reveals, if there emerges an uncontrollably strong drive or motive, behavioural control is thought to be ineffective and the most successful measures to control it should be based

on physical operation.

4–4. Excessive speeding

The maximum speed allowed by law on expressways in Japan is 100 km/h. Simply put, nobody may drive at speeds faster than that. In spite of this, almost every car has a maximum of 180 km/h on its speedometer. The maximum speed is controlled by a speed limiter. Japanese car manufacturers have independently limited the maximum speed of cars to 180 km/h, and power to 280 hp, for the past ten years. There had been no limits on speed performance in vehicles until then. Social pressure by an association of children whose parents had been killed in traffic accidents worked as a trigger for this self-regulation. However, there still remains the question of whether or not the limit of 180 km/h is sufficient. For what purpose is such excessive speed needed? What does the traffic law regarding speed intend? Is the latter no more than a formality? What is the real intention? Even more surprising is a recent movement to eliminate the self-regulation provided by the 180 km/h limiter.

With regard to this point, police control of speeding offers an important hint. Police patrol cars sometimes go at a faster speed than the limit even under ordinary conditions. They won't stop those private cars which are obviously speeding. On the other hand, some cars going at a speed only 10 km/h over the limit are stopped if they are unfortunate enough to run into a speed trap, and the drivers have to pay a large fine. An even more surprising thing is the speed standards of automatic 'speed trap' cameras. They usually don't work unless a car exceeds the limit of the stretch by more than 20 to 30 km/h. Thus many cars drive at speeds much faster than the limit in some sections of roads. Consequently, official policy on speed violation seems to be very complicated in Japan.

4–5. ISA: Intelligent Speed Adaptation

The most effective measure to control the maximum speed of a car is to introduce an external traffic system. Taniguchi (1993a) proposed a kind of ITS to limit the maximum speed on ordinary roads and expressways respectively, which was named MASCOS (Maximum Speed Control System). The system is mandatory and drivers can never surpass the maximum speed on each section of road. All the ordinary cars must be equipped with the system and are never allowed to remove the speed limiter. Only a part of public vehicles like patrol or ambulance cars are able to go without the limiter. The basic technology is considered to be already at practical level, conjectured from technologies actually being in use as ETC (Electronic Tall Collecting System), Cruise Control System, and so on. Although it is not easy to find the proper and acceptable speed limit, and we need a lot of argument to reach consensus, the maximum speed on ordinary roads can be set to 70 km/h and on expressways to 140 km/h, for example. The expected effect of the system was that more than fifteen percent of lives would be saved when the speed limiting traffic system was introduced compulsorily to all the vehicles (Taniguchi, 1993b). Social acceptance of the traffic system seems to be promising, for some questionnaire survey showed that around 70% were in the affirmative with regard to legislation of the system. That attitude was strongly supported by the ethical view point (Taniguchi, 1998).

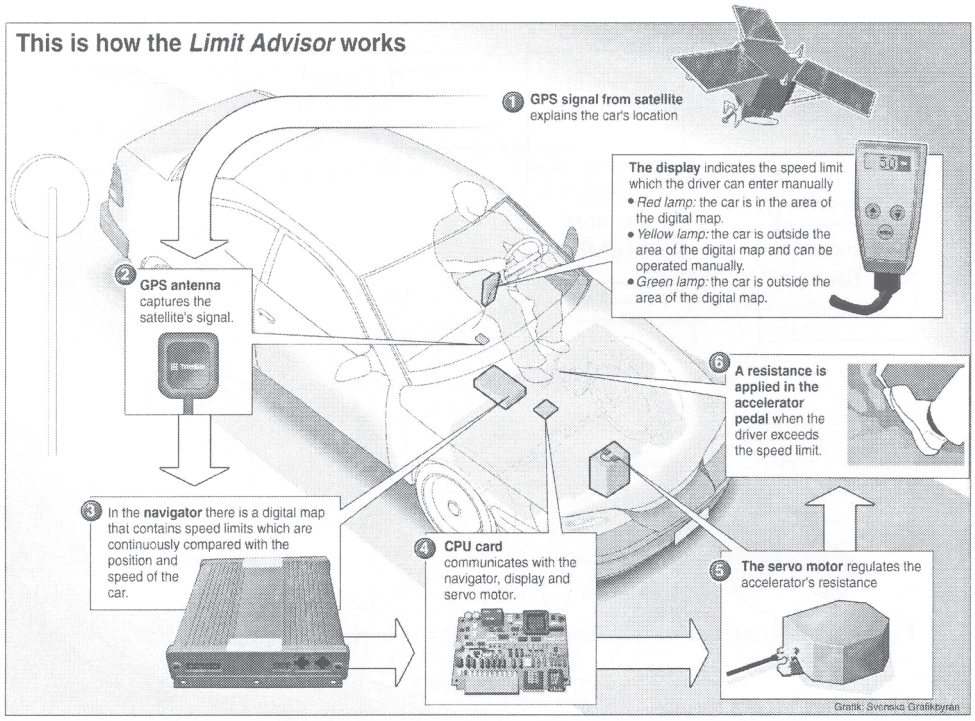

Figure 2 This is how the Limit Advisor works: the equipment used in the large scale experiment of ISA in Lund (galileo's World, 2001)

On the other hand, researches on the speed limiting traffic system in Europe have been more active and wide ranged. The Lund Institute of Technology in Sweden started the research in the 1980s, and found the speed limiting traffic system can be an effective measure to control speeding (Várhelyi, 1996, etc.). In 2000, they started a large scale trial of ISA in accordance with Swedish government politics, Vision Zero which aims that nobody should need to be killed or seriously injured by traffic accidents (Swedish National Road Administration, 1999). More than 230 cars in Lund city were equipped with the ISA system for one year. The system decides the maximum speed of a car automatically and compulsorily using GPS and a digital map inside a car (Figure 2). The experiment was completed at the end of 2001 and the final report will be published soon.

Other countries such as England, Netherlands, Norway, Denmark, Finland and Australia, etc. are conducting similar field experiments as well (Carsten, 2002). EWGOSC (European Working Group on Speed Control) is the network for the research co-operation. In May of 2002, the first workshop on Speed Control was held in Nagoya which was partly jointed by the annual conference of Japanese Association of Traffic Psychology to introduce the basic concepts and the results of the newest field experiments to Japanese researchers (Hydén, 2002; Risser, 2002). Some research and actual activities on speed limiting in Japan such as Soft Car Millennium Project Team (Oguri, 2002) and Police section were also reported.

5. Conclusion

5–1. Basic research and application

This section's purpose is applied research. Evaluation should be performed from the perspective of whether it has actually succeeded in reducing the number of accidents and the amount of injury. Of course this does not mean that all research should directly connect to actual deterrent measures and should have an effect. Basic research includes describing the components of each phenomenon and analyzing the mechanism of the phenomenon under operationally defined conditions. It is not easy to find clearly which research will be fruitful for countermeasures against various types of accidents. However, this kind of research is still necessary and important. It is important for the researchers to have the viewpoint that their research could finally lead to the suppression of accidents.

Some comments on the relation between basic research and applied research: experimental research in a laboratory is typical of basic research. The conditions are strictly controlled by the factors which are regarded as relating to the phenomenon being studied. Experiments clarify the mechanism of factors on the phenomenon. Thus the result is one under experimental conditions, and the same result can never be obtained unless the conditions are the same as the experiment. In actual daily life situations, these assumptions cannot easily be satisfied, only rarely being the same. In actual situations, human behaviour especially is decided by various factors. In some cases unpredictable factors can be added. It is meaningless, and not easily permitted, to intentionally control the conditions of people. Control should be limited under the carefully considered regulations.

Nevertheless, experimental knowledge still has concrete meaning, for it is almost impossible to find a means of accessing the understanding of human behaviour without results from the laboratory. The important thing is to know how to introduce what kind of experimental knowledge in practice. There are no fixed ways, for actual situations are too complicated to show which is best. You should be flexible and ready to introduce any knowledge obtained by any research approaches. In other words, nobody knows the best way and you should select knowledge from basic research, then try to modify the method, fitting it to actual situations. Then you can search for other research or refine the method to deal with the problem better, after obtaining feedback from the trial. You should not stick to a particular principle, methodology, or theory. It is rare that they produce useful results. When you find it necessary to clarify the function of a given factor, you should return to the preliminary stage and conduct analysis.

5–2. The meaning of an accident and the role of government

Accidents only happen when all the necessary factors are present, but such situations are very rare. That is the reason why they are called accidents. However the statistics reveal a constant number of accidents if calculated for a year and a large number of people. The word accident is for the individual but not for society. The governmental organisation of a society must grasp the actual situation of traffic accidents, and should prepare for prevention and deal with the results.

5–3. Deterrent measures against accidents and social consensus

In order to situate deterrent measures against traffic accidents socially, rather than simply an individual, system, it is necessary to wait until sufficient discussion has developed and a kind of consensus is obtained. The content or process of discussion and consensus are different depending upon the kind of groups that conduct them, starting from the minimum group of a family, and proceeding up through the residential community, office, town or city, and to the nation. A general principle could be adopted to understand how traffic safety politics develop. Thus this problem relates to social, group and organisational Psychology.

To put it concretely, it is a problem of how traffic safety policy develops. Based on the armchair ideal, democratic process is the best. However, in many cases, people don't have a political attitude to the problem if it is not one they regard as critical. Thus it is rather difficult to implement the ideal policy. On the other hand, it is common for a few people who have a strong interest in the problem to work hard and campaign actively, whether for or against. At the national policy level, the traffic problem is in the same line as many other problems. It has some other aspects: economic, industrial and so on. Thus it is not decided based only on ethics, but typically on life itself. Some political parties argue the advantages and disadvantages of a policy for their supporters. Sometimes a policy is used as material for making a deal with other parties. The mass media have another kind of power, for they have the possibility to change the direction of nationwide argument.

In any case, it is most important that someone finds what is the most urgent problem to be solved and shows it to the public. The problem of traffic accidents concerns the most important topic of human safety, and most of all, life. This point of view is fundamental and many people, even if they are not political, should agree with the principle. A mountain of research results have been accumulated, but few are applied to actual daily life. The government has great power to decide to use them.

References

Almqvist, S. and Nygård, M. 1997 Dynamic speed adaptation—A field trial with automatic speed adaptation in an urban area. *Department of Traffic Planning and Engineering, Lund Institute of Technology, Lund University, Bulletin 154*.

Bladh, S. and Svensson, P. 2001 Take It to the Limit. *galileo's World*, 3(2), 14–40.

Carsten, O. 2002 European Research on ISA: Where are we now and what remains to be done. *Paper presented at the ICTCT, JATP, EWGOSC workshop on Intelligent Speed Adaptation in Nagoya-Japan*.

Chaloupka, C. and Risser, R. 2002 Demands on Traffic Psychologists in Europe. *Keynote lecture at the 65th convention of the Japanese Traffic Psychology Association*.

Fujimoto, T. and Higashi, M. 1996 A study on scale construction of young drivers' driving attitude. *Japanese Journal of Traffic Psychology*, 12(1), 25–36. (in Japanese)

Gale, A. G. (Ed.) 1996 *Vision in Vehicles—V.* North Holland.

Gaudry, M. and Lassarre, S. (Eds.) 2000 *Structural Road Accident Models*. Pergamon.

Hale, A., Wilpert, B. and Freitag, M. (Eds.) 1997 *After the Event: From Accident to Organisational Learning*. Pergmon.

Hauer, E. 1997 *Observational Before-after Studies in Road Safety*. Pergamon.

Hydén, C. 1987 The development of a method for traffic safety evaluation: The Swedish Traffic Conflicts Technique. *Department of Traffic Planning and Engineering, Lund Institute of Technology, Lund University, Bulletin 70*.

Hydén, C. 2002 ISA—a shift of paradigm in speed management. *Keynote lecture at the 65th convention of the Japanese Traffic Psychology Association*.

Klebelsberg, D. 1982 *Traffic Psychology*. Springer Verlag.

Lamm, R., Psarianos, B. and Mailaender, T. 1999 *Highway Design and Traffic Safety Engineering Handbook*, McGraw-Hill.

Mackenna, F. P. and Crick, J. L. 1991 Experience and expertise in hazard perception. In G. B. Grayson and Lester, J. F. (Eds.) *Behavioural Research in Road Safety*, 39–46, Transport and Road Research Laboratory, Crowthorne.

Mackenna, F. P. and Crick, J. L. 1993 A cognitiv-psychological approach to driver training: the use of video technology in developing the hazard perception skills of novice drivers. In G. B. Grayson (Ed.) *Behavioural Research Laboratory*. Crowthorne.

Management and Coordination Agency of Japan 1997 *Traffic Safety White Paper in 1997*. Department of Printing in the Ministry of Finance.

Management and Coordination Agency of Japan 2002 *Traffic Safety White Paper in 2002*. Department of Printing in the Ministry of Finance.

Matsunaga, K. 1998 Study on traffic accident prevention based on KM model. *Automobile Management*, 25(9), 4–15. (in Japanese)

Miura, T. 1986 Coping with simulational demands: A study of eye movements and peripheral vision. In A. G, Gale, et al. (Eds.) *Vision in Vehicles*. Elsevier Science Publishers.

Oguri, Y. 2002 Soft Car and Safe Traffic System: Development of Maximum Speed Indicator and Speed Limiter and Social Experiment. *Paper presented at the ICTCT, JATP, EWGOSC workshop on Intelligent Speed Adaptation in Nagoya-Japan*.

Risser, R. 2002 ISA—a solution to psychological problems with speed choice. *Keynote lecture at the 65th convention of the Japanese Traffic Psychology Association*.

Rothengatter, T. and Carbonell Vaya, E. (Eds.) 1997 *Traffic and Transport Psychology: Theory and Application*. Pergamon.

Schmidt, F. and Tiffin, J. 1969 Distortion of drivers' estimates of automobile speed as a function of speed adaptation. *Journal of Applied Psychology*, 53, 536–539.

Swedish National Road Administration 1999 *Leaflet for a large scale trial of Intelligent Speed Adaptation*.

Taniguchi, S. 1993a Analysis of speed as the cause of car accident: A proposal of preventative measures against death accident by maximum speed limiter on ordinary roads. *Paper presented at the 57th convention of the Japanese Psychology Association*. (in Japanese)

Taniguchi, S. 1993b Preventative effect of car accident by maximum speed control system. *Paper presented at the 48th convention of the Japanese Traffic Psychology Association*. (in Japanese)

Taniguchi, S. 1998 Attitudes toward Maximum Speed Control System of a car. *Paper presented at the 58th convention of the Japanese Traffic Psychology Association*. (in Japanese)

Taniguchi, S. 1999 *Basic Idea of Maximum Speed Control System in Japan*. 12th ICTCT (International Co-operation on Theories and Concepts in Traffic Safety) Workshop, University of Kaiserslautern, Germany.

Taniguchi, S., Omata, K., Ohnogi, H., Takahashi, K. and Hanari, T. 1992 *Report of Commissioned*

Research by the Headquarters of Aichi Prefectural Police in 1991: Surveying and analyzing study of drivers behaviour: Death accident. The Headquarters of Aichi Prefectural Police. (in Japanese)

Uchida, N. and Katayama, T. 2001 Peripheral visual functions and cross traffic intersection accidents. *Japanese Psychological Review*, 44(1), 37–46. (in Japanese)

Várhelyi, A. 1996 Dynamic speed adaptation based on information technology: a theoretical background. *Department of Traffic Planning and Engineering, Lund Institute of Technology, Lund University, Bulletin 142*.

Wilde, G. J. S. 1994 *Target Risk: Dealing with the danger of death, disease and damage in everyday decisions*. Tront: PDE Publications.