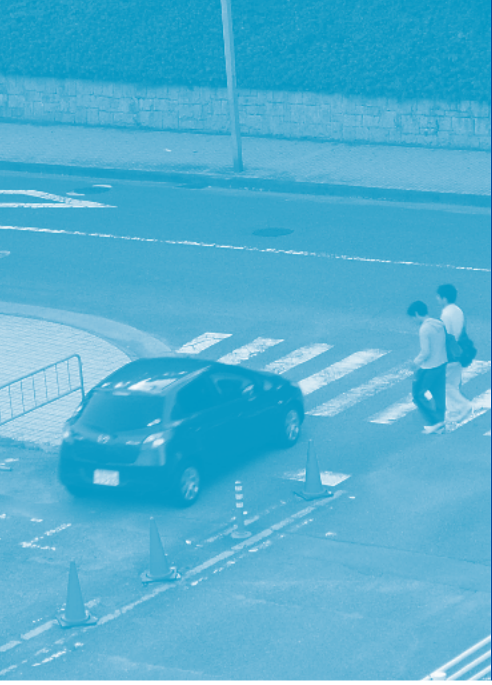

Chapter 8

Traffic psychology

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8.1 Perception and cognition of drivers

When operating a vehicle, drivers gather information from the surroundings based on their intended purpose and process the information accordingly to operate the steering, pedals, and switches. Although this appears to be a series of simple tasks, these actions involve various mental processes such as predicting changes in the surrounding environments, gathering information for subsequent actions, and detecting and handling dangerous situations. The process of gathering external information is defined as perception, and the process of understanding and handling the external information is defined as cognition. The perception and cognition of massive amounts of information is performed largely automatically and unconsciously, in accordance with complex rules and under strict time limits. These mental processes, which are performed without any errors, are critical for safe driving.

As in Figure 1, all human behaviors, not limited to driving, are represented in a schematic diagram.[1)] According to this model, human behaviors involve three levels of information processing (skill-, rule-, and knowledge-based) between the input of information and the output of action. The perceptual features of sensory information obtained via the sensory organs are analyzed to recognize the content of the information. If the content is already well-known, appropriate responses are elicited quickly at

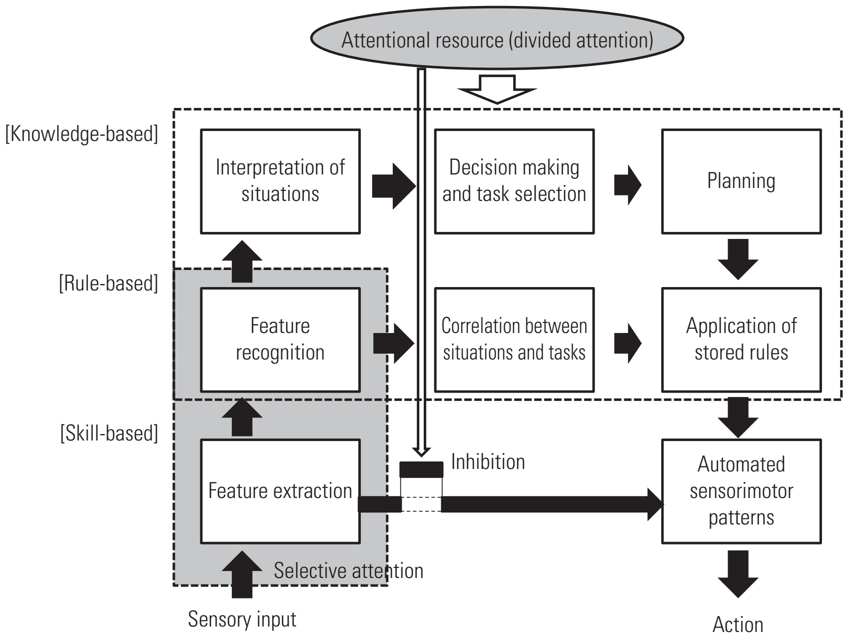

Figure 1. Three-level behavior control model based on Rasmussen's SRK model

the point of feature formation. This skill-based response is rapid and unconscious but is also fixed and inflexible. When it is necessary to behave in accord with informational content, rules for selecting a response are recalled in order to behave appropriately. Attention is not required when the behavior to be performed is simple and familiar, whereas a certain degree of attention is required when the behavior is unfamiliar. When the information is novel and totally unfamiliar, information processing is "knowledge-based," which is a conscious process to interpret information and make behavioral decisions. A behavior at this level can be slowly but flexibly controlled, and requires sufficient attention.

Most basic driving operations, such as steering and pedal operation, are controlled at the skill-based level, while rule-based processing is required when drivers have to think about driving. For example, drivers have to behave at the knowledge-based level when they encounter an irregular road situation in which the road priority is unclear and when they have to make a route to the destination. In models of driver behavior, hierarchical concepts (operational, tactical, and strategic) have been used to explain driver behavior.[2)] In particular, the operational and tactical levels apparently correspond to the skill- and rule-based levels, respectively.

In addition, attention plays an important role in driving. Attention may be classified into selective attention for selectively gathering information and divided attention for working as mental energy to execute actions. The cognitive process in which these two processes are deeply involved is also shown in Figure 1.

8.2 Hazard perception

A hazard is a source of danger that may cause an accident, and hazard perception is defined as the detection of hazards and the recognition of their characteristics while operating a vehicle. Hazards are divided into overt hazards (e.g., visible pedestrians ahead) and latent hazards (e.g., unseen pedestrians in blind spots), and hazards need to be detected in a timely manner. Hazard perception may also be regarded as a situational awareness step required for securing safety.[3)]

When operating a vehicle, hazard perception relies for the most part on vision. To capture hazards by central vision, which is highly effective but limited to a narrow area, visual information must be obtained by looking at places where the presence of hazards is highly probable, while anticipating and paying careful attention to the appearance of hazards. Selection of visual information is strongly affected by drivers' expectations and value judgments. If a driver has insufficient intention to detect hazards, "inattentional blindness" can occur, which is a phenomenon where visible objects are viewed but overlooked.[4)]

Drivers are also required to quickly determine which elements or situations are hazardous based on their experiences and knowledge. To do so, drivers must be able to store hazardous experiences, scan the contents quickly, and recall the experiences. Drivers gradually acquire hazard-related knowledge through driving experiences and develop a schema about hazards. Schemas are generated based on the past experiences of events, actions, and objects, and are constructed with a number of generalized concepts.[5] Behavior control by schemas is generally an unconscious and automatic process,[6] and schemas compensate for insufficient information by using default values.[5] Schemas are the basis for smooth human behavior. By constructing schemas, drivers can recognize scenes containing hazards more correctly and comprehensively, as shown by previous studies.[7, 8]

For preventing accident, it is extremely important to perform hazard perception effectively. Consequently, various hazard perception tests have been developed and incorporated into driver's license examinations in Western countries as well as in Japan.[9] In a typical hazard perception test, drivers observe a video of the view from the driver's seat and push a button as soon as they discover a hazard. Drivers' hazard perception ability is evaluated based on the time taken to detect and react to a hazard and the overall detection rate. In general, skilled drivers have short detection and reaction times and a high detection rate compared with novice drivers.[10, 11] Previous studies of eye movements during hazard perception testing suggest that the difference in reaction time between skilled and novice drivers is due to the difference in time taken to process and determine the degree of hazard rather than the difference in their respective abilities to detect hazards.[12, 13]

In addition, due to the increasing number of elderly drivers, research is currently underway to investigate age-related changes in hazard perception ability. While some studies have shown that hazard perception test scores are low among elderly drivers compared with younger drivers,[14, 15] other studies have revealed no age-related difference in hazard perception abilities.[16] Further studies are needed to clarify whether hazard perception test scores among elderly drivers are affected by a decline in visual function itself (e.g., a decline in contrast sensitivity); a reduction in the useful field of view, which is indicative of an overall decline in the mechanism of attention; or age-related modifications in the structure and mechanism of the schema that is the basis of hazard perception.

Educational and training programs are offered to improve hazard perception ability. One of the methods is to point out hazards hidden in still images and videos of traffic scenes. As mentioned earlier, hazard perception is based on a schema constructed with a variety of knowledge regarding dangers. To perform hazard perception effectively, drivers should not only memorize extensive knowledge about typical and individual hazards and immediately retrieve knowledge appropriate for a particular scene, but also generalize such knowledge to meet novel situations. Therefore, it is necessary to educate drivers and give them an understanding of the processes by which hazards cause accidents and the information that makes hazard detection easier, rather than simply teaching them how to respond to individual hazards. For example, driving schools in Japan already provide hazard perception training in the form of discussion-based training on hazard prediction and driving while predicting hazards. To improve hazard perception education, the incorporation of psychological approaches based on the perceptual and cognitive processes of hazard prediction into the content of driver's education should be considered.

8.3 Risk taking

In traffic psychology, the term "risk taking" has long been used as a concept associated with accidents based on the assumption that accidents are more likely caused by drivers with a tendency to act despite being aware of potential risks. In particular, risk taking is given as the reason for high accident rates among young drivers.

When individuals exhibit a tendency toward taking risks, they may behave in the same way but for different reasons; some enter risky situations without knowing what is dangerous, while others take risks despite being aware of the danger, for example to seek thrills. When drivers enter intersections against a red traffic signal, they may do so with or without being aware of the signal. From the perspective of individual traits, the former may have problems with hazard perception, while the latter may have behavioral problems, such as a risk-taking tendency.

Trimpop defines risk taking as all actions that are engaged at the time of perceiving elements of uncertainty or possibility of loss.[17] Accordingly, almost all traffic behaviors involve risk taking due to the uncertainties associated with such behaviors compared with other ones in daily life.

Traffic behaviors reflect mental processes performed under extremely high time pressure, and their features affect risk-taking behaviors. Driving and traffic behaviors are characterized by the rapidity and continuity of the process between hazard or risk perception and risk taking via decision making.

As covered in the previous section, good hazard perception ability, for foreseeing and detecting in advance the objects or situations that may lead to accidents, is essential for safe driving. However, the risk of potential accidents linked to one's own driving is evaluated with respect to those hazards in a comprehensive manner. If one's driving skills are judged to be sufficient to handle driving challenges, then risks are evaluated as being low even though hazards are perceived correctly.

However, even when risks are evaluated to be high, if utility such as shortened time or increased admiration from others is judged more important, it is likely that the risks will be accepted and risk-taking behaviors will emerge. If gains are made by engaging in high-risk behaviors, the risks are rewarded, generating positive reinforcement. For example, if the time required to reach the destination is shortened by traveling at high speed, then the behavior is rewarded. In other words, driving behaviors are associated with gains due to stress release and rushed driving. This quality, where gains exert an effect on risk taking or risk avoidance behaviors, is called risk utility.

Human motivation involves various types of risk utility, such as releasing stress, violence, expressing independence, increasing arousal levels, increasing on-road travel efficiency (in a hurry to reach one's destination), rebelling against adult authorities, and receiving admiration from peers. Furthermore, compared with middle-aged individuals, young individuals tend to attach importance to appearance and style, but not safety features, when purchasing a car. These motivations often affect risk-avoidance behavior.

Particularly in recent years, sensation seeking has been attracting a lot of attention. According to Zuckerman, sensation seeking is defined as an individual trait that plays a role in seeking various, novel, complex, and intense sensations or experiences and for taking physical, social, legal, and financial risks to gain such experiences.[18] According to this definition, sensation seeking is nothing but a motivation for taking risks.

As the knowledge of risk utility increases, it has become apparent that the improvement of risk perception alone is not enough to reduce the risk-taking tendency or increase the risk-avoidance tendency of drivers. To understand why drivers behave in certain ways, it is important not only to study the possibility of accidents as risk non-utility, but also to simultaneously take into account risk utilities, including sensation seeking and admiration of others.

Most active discussions regarding risk acceptance and avoidance in recent years are about the issues surrounding the theories of risk compensation and risk homeostasis. Risk compensation is a tendency of traffic participants to offset or reduce the merits of safety measures by engaging in risky behavior. For example, even when the safety of streets is improved, traffic participants may partly negate these safety benefits by behaving negatively, such as increasing the speed of the vehicle and failing to perform safety checks.

According to the theory of risk homeostasis proposed by Wilde,[19)] we as individuals set target risk levels for various activities and modify our behaviors to achieve or maintain these levels. As a result, the number of accidents will not be reduced unless safety measures are designed to decrease target risk levels, suggesting that behavior moves towards danger to the same extent as does the merit generated by the safety measure. However, risk homeostasis theory is often criticized because it is unlikely that individual drivers can estimate safety merits accurately.

8.4 Behavior and education of elderly drivers

As it is a challenge associated with an aging society, the prevention of accidents among elderly drivers is discussed actively. However, careful discussions are needed to clarify whether elderly drivers are indeed high risk compared with younger drivers, because even with some form of functional decline, elderly drivers are able to reduce the actual risk of accidents by avoiding high-risk driving (driving at night or in rain) or driving carefully, for example, by slowing down. Such "compensatory driving" behaviors among many elderly drivers have already been demonstrated by many studies.

However, research has also revealed that the accident rate for a given driving distance is higher among elderly drivers compared with other age groups, except for young adults. According to Fujita, the number of fatal accidents and traffic accidents among elderly drivers is respectively 3 and 1.5 times that of other age groups excepting young adults.[20)]

Poor driving performance is thought to be the reason for high accident rates among elderly drivers. Using behavioral indicators (safety checking behavior and speeding behavior) and driving assessment indicators used by instructors to evaluate the driving performance of elderly drivers, Renge et al. revealed that the number of times elderly drivers looked to the right and left for oncoming traffic was fewer than that of drivers in other age groups[14)] (Fig. 2). Although no age-related difference was observed in the speed during routine driving, at the intersections with a stop sign, elderly drivers drove faster at intersections with poor visibility or stop signs, compared with other age groups, indicating that many elderly drivers fail to perform one of the safe driving basics: stopping to check traffic.

However, as mentioned earlier, many studies have reported that elderly drivers counterbalance functional decline and the deterioration of their driving performance with compensatory driving behavior. Matsuura, Ishida, and Mori developed the safe driving workbook, which includes dangerous driving scales and compensatory driving scales to test their hypothesis that elderly drivers engage in compensatory driving behaviors to avoid dangerous situations upon realizing potentially dangerous driving performance due to functional decline.[21] Their study revealed that dangerous driving and compensatory driving scores increased with age. Furthermore, as the scores for dangerous driving increased, elderly drivers were involved in more accidents and committed more violations, and their driving behaviors were rated lower by instructors.

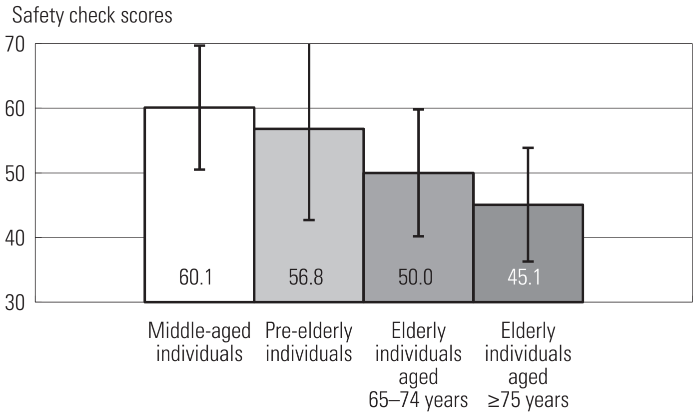

Figure 2. Safety check scores by age group

A previous study performed at a driving school has shown the effectiveness of a program that educates elderly drivers how to comply with stop signs and verify traffic safety.[22] The educational program was developed because elderly drivers are generally not good at stopping at stop signs or checking traffic safety. In this program, using the behavior check and feedback approach, (1) elderly drivers drove through the predetermined course at the school using one of the school cars, and their performance was videotaped (performance-based diagnosis), and (2) elderly drivers evaluated their driving behavior on the video and received feedback from the instructors.

After converting this educational method into a practical coaching method, developing an educational manual for instructors, and training them, Renge et al. asked appropriate questions and provided feedback to cause program participants to recognize their own problems.[23] In the program, participants slowed down at intersections and increased their number of traffic safety checking steps compared with non-participants (Fig. 3). The efficacy weakened but persisted over one month after the program.

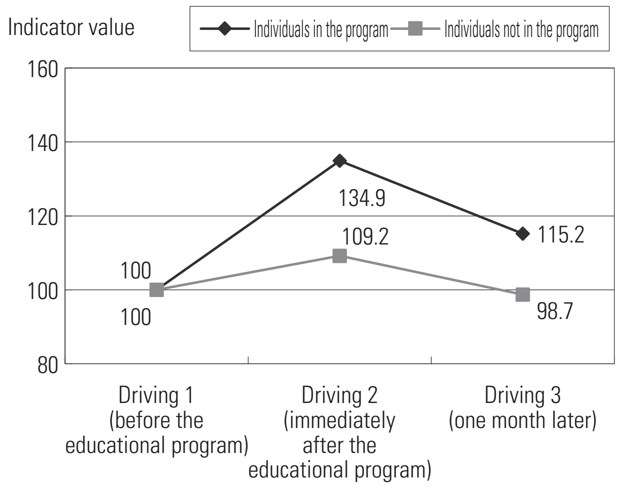

Figure 3. Educational efficacy in terms of total number of safety checks

Although it is sometimes questioned whether educational programs for elderly individuals are effective, a certain level of efficacy can be expected with the use of this method, where program participants check their own driving performance and receive appropriate feedback.

8.5 Behavior and education of bicycle users

The rate of bicycle-related accidents is high among children and elderly individuals, and failing to stop at stop signs, ignoring traffic signals, traveling the wrong way, and crossing streets inappropriately have been indicated as potential reasons. Furthermore, analysis performed by the International Association of Traffic and Safety Sciences (IATSS) in 1995 and adjusted for the number of licensed drivers and for traveling time has shown that elderly individuals with no driver's license have a high rate of accident.[24) Although a similar trend is observed among young and middle-aged individuals, the problem is more serious for elderly individuals because of the low proportion of licensed drivers in this group.

In 2012, the IATSS also conducted a study using the driving lanes at a driving school to investigate behavioral characteristics such as stopping and checking the safety at intersections.[25) The study evaluated where bicycles traveled in their lane and safety checking behavior (how many times bicycle users looked to the right and left at intersections, and how thoroughly they did so).

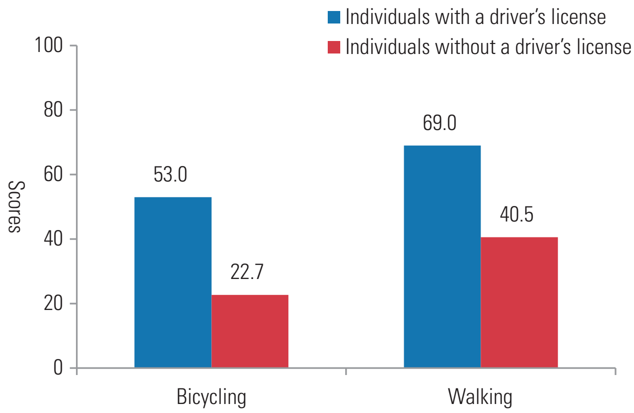

Figure 4. Effect of obtaining a driver's license on total safety check scores for bicycling and walking

Figure 4 shows the effect of obtaining a driver's license, which includes the benefits of driving experience and drivers' education. The results indicate that higher safety check scores at intersections were obtained by bicycle users with a driver's license than by those without. The former also scored higher for location of their bicycle on the road, showing that they choose to travel closer to the roadside than the latter did.

However, bicycle users without a driver's license set low standards for safety checking, the location of their bicycle, and driving behavior, thereby showing high-risk behavior, when riding a bicycle compared with when walking. We interpreted this to mean that elderly bicycle users who have a driver's license can readily engage in appropriate risk avoidance behavior, owing to driving skills and knowledge previously acquired at driving school or through their own driving experiences. The early establishment of educational programs for bicycle users that are equivalent to driver's education programs may reduce accidents among bicycle users who do not have a driver's license, and therefore, proactive educational programs should be provided in cooperation with schools and local traffic safety associations.

Using an observational and coaching method, Ogawa developed a bicycle education program for high school students based on his hypothesis that a lack of awareness of one's behavior and role as a cyclist is a factor causing unsafe behaviors.[26) By applying the basic principles of coaching, observation of others was performed in several steps such as group discussions, video viewing, and bicycling simulation. Before and after the educational program, high school students created 20 self-awareness sentences starting with "I" using the 20-responses technique. Comparison of the sentences revealed that although the students provided general bicycling-related descriptions before the program, they increased both the number of statements and the descriptions about proactively securing safety, especially the safety-checking category, after the program. Such bicycling education programs that enhance self-awareness should be promoted because they are suited for and benefit adolescent individuals who are transitioning into adulthood, and provide lifelong benefits.

References

1) Shinohara, Kazumitsu. 2011. "Chui to hyuman era: Kotsu anzen to chui mondai o chushin toshite" [Attention and human error: On traffic safety and attention problem]. In *Theories and Applications of Cognitive Psychology 4: Attention and Safety*, edited by Etsuko Harada, and Kazumitsu Shinohara, 186–208. Kitaohji Publishing. (in Japanese)
2) Shinar, D. 2007. *Traffic safety and human behavior*. Elsevier.
3) Horswill, M. S., and F. P. McKenna. 2004. "A cognitive approach to situation awareness." In *A cognitive approach to situation awareness: theory and application*, edited by Banbury, S., and S. Tremblay. Ashgate publishing.
4) Chabris, C., and D. Simons. 2010. *The invisible gorilla: and other ways our intuitions deceive us*. HarperCollins Publishers.
5) Shinohara, Kazumitsu. 2013. "Ninchi to hyuman era" [Cognition and human error]. In *Human Factors Psychology for a New Era of Safety and Comfort*, edited by Kazumitsu Shinohara, and Takahiro Nakamura, 41–59.Yuhikaku Publishing. (in Japanese)
6) Harada, Etsuko, and Takatsune Kumada, Kazumitsu Shinohara, eds. 2013. "Chui to suikou kinou" [Attention and executive function]. In *The handbook of cognitive psychology*, edited by The Japanese Society of Cognitive Psychology, 94–95. Yuhikaku Publishing. (in Japanese)
7) Benda, H. V., and C. G. Hoyos. 1983. "Estimating hazards in traffic situations." *Accident Analysis and Prevention* Vol. 15: 1–9.
8) Borowsky, A., T. Oron-Gilad, and Y. Parmet. 2009. "Age and skill differences in classifying hazardous traffic scenes." *Transportation Research Part F: Traffic Psychology and Behaviour* Vol. 12: 277–287.
9) Nagayama, Yasuhisa. 2009. *Kanrisha no tameno kiken yosoku unten kyoiku: nichi, bei, o no kikenyosoku kyoiku to kyozai, tesuto mondai* [Driver's risk prediction education for instructors: The comparison of materials and tests for the risk prediction education among Japan, the United States, and Europe]. Kigyo Kaihatsu Center. (in Japanese)
10) Scialfa, C. T., M. C. Deschênes, J. Ference, J. Boone, M. S. Horswill, and M. Wetton. 2011. "A hazard perception test for novice drivers." *Accident Analysis and Prevention* Vol. 43: 204–208.
11) Borowsky, A., D. Shinar, and T. Oron-Gilad. 2010. "Age, skill, and hazard perception in driving." *Accident Analysis and Prevention* Vol. 42: 1240–1249.
12) Huestegge, L., E. M. Skottke, S. Anders, J. Müsseler, and G. Debus. 2010. "The development of hazard perception: Dissociation of visual orientation and hazard processing." *Transportation Research Part F: Traffic Psychology and Behaviour* Vol. 13: 1–8.
13) Wetton, M. A., M. S. Horswill, C. Hatherly, J. M. Wood, N. A. Pachana, and K. J. Anstey. 2010. "The development and validation of two complementary measures of drivers' hazard perception ability." *Accident Analysis and Prevention* Vol. 42: 1232–1239.
14) Renge, Kazumi, Tomikazu Ishibashi, Masaaki Oiri, Hiro Ota, Shigeyuki Tsunenari, and Marehiro Mukai. 2003. "Korei doraiba no unten pafomansu to hazado chikaku" [Driving performance and hazard perception of elderly drivers]. *Japanese Journal of Applied Psychology* Vol. 29, No. 1: 1–16. (in Japanese)
15) Renge, Kazumi, Masahiro Tada, and Marehiro Mukai. 2014. "Korei doraiba to chunen doraiba no risuku tekingu kodo ni kansuru jisshoteki kenkyu" [Empirical study on the risk taking behavior by elderly and middle-aged drivers]. *Japanese Journal of Applied Psychology* Vol. 39, No. 3: 182–196. (in Japanese)
16) Underwood, G., N. Phelps, C. Wright, E. van Loon, and A. Galpin. 2005. "Eye fixation scanpaths of younger and older drivers in a hazard perception task." *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians (Optometrists)* Vol. 25: 346–356.
17) Trimpop, R. M. 1994. *The psychology of risk taking behavior*. North-Holland.
18) Zuckerman, M. 1994. *Behavioral expressions and biosocial bases sensation seeking*. Cambridge University Press.
19) Wilde, G. J. S. 2001. *Target risk 2: a new psychology of safety and health*. PDE Publications.

20) Fujita, Goro. 1996. "Kotsujiko ritsu, kikenbakuro do oyobi untenkodo no nenrei ni yoru chigai" [Difference in the ratio of traffic accidents, the degree of danger exposure, and driving behaviors based on age]. *Reports of the Scientific Police Research Institute. Research on traffic safety and regulation* Vol. 37, No. 2: 48–57. (in Japanese)
21) Matsuura, Tsuneo, Toshiro Ishida, and Nobuaki Mori. 2008. *Korei doraiba no tameno anzen unten wakubukku* [The Safe Driving Workbook for elderly drivers]. Kigyo Kaihatsu Center. (in Japanese)
22) International Association of Traffic and Safety Sciences. 2004. *Korei doraiba eno kyoiku puroguramu to shien shisutemu no kaihatsu: heisei 15 nendo kenkyu chosa hokokusho* [Development of educational programs and a support system for elderly drivers: research report 2003]. International Association of Traffic and Safety Sciences. (in Japanese)
23) Renge, Kazumi, Hiro Ota, Marehiro Mukai, and Kazuhisa Ogawa. 2010. "Kochingu ho o mochiita korei doraiba eno kyoiku puroguramu no koka" [The effectiveness of educational programs for elderly drivers using a coaching method]. *Japanese Journal of Traffic Psychology* Vol. 26, No. 1: 1–13. (in Japanese)
24) International Association of Traffic and Safety Sciences. 1995. *Korei hokosha, jitensha joyosha no anzen ni taisuru unten-keiken no koka ni kansuru chosa kenkyu: heisei 6 nen kenkyu chosa hokokusho* [Research study on the effectiveness of driving experience of elderly pedestrians, cyclists, and drivers against safety: research report 1994]. (in Japanese)
25) International Association of Traffic and Safety Sciences. 2012. *Kodomo kara koreisha madeno jitensha riyosha no shinri kodo tokusei o fumaeta anzen taisaku no kenkyu (III): kenkyu chosa purojekuto hokokusho* [Study of safety measures based on the psychological and behavioral characteristics of cyclists from children to the elderly: a report of research project]. (in Japanese)
26) Ogawa, Kazuhisa. 2014. "Method Development for Safety Education Based on Students' Self-Understanding." *Memoirs of the Tohoku Institute of Technology: Ser. II: Humanities and Social Sciences* Vol. 34: 1–9. (in Japanese)

Recommended Reading

1) Wickens, C. D., and J. S. McCarley. 2008. *Applied attention theory*. CRC Press.
2) McKenna, F. P., and M.S. Horswill. 1999. "Hazard perception and its relevance for driver licensing." *IATSS Research* Vol. 23: 36–41.
3) Endsley, M.R. 2000. "Theoretical underpinnings of situation awareness: a critical review." In *Situation awareness analysis and measurement*, edited by M. R. Endsley, and D. J. Garland, 3–28. Lawrence Erlbaum Associates.
4) Marottoli, R.A., and E. D. Richardson. 1998. "Confidence in, and self-rating of, driving ability among older drivers." *Accident Analysis and Perception* Vol. 30: 331–336.
5) Marottoli, R. A., E. D. Richardson, M. H. Stowe, E. G. Miller, L. M. Brass, L. M. Cooney Jr., and M. E. Tinetti. 1998. "Development of a test battery to identify older drivers at risk for self-reported adverse driving events." *Journal of American Geriatrics Society* Vol. 46, No. 5: 562–568.
6) Matsuura, T. 2011. "Older drivers' risky and compensatory driving: Development of a safe driving workbook for older drivers." In *Traffic Psychology: An International Perspective*, edited by D. Hennessy, 87–113. Nova Science Publishers.
7) Oxley, J., B. Fildes, B. Corben, and J. Langford. 2006. "Intersection design for older drivers." *Transportation Research Part F: Traffic Psychology and Behaviour* Vol. 9: 335–346.
8) Renge, K. 1998. "Drivers' hazard and risk perception, confidence in safe driving, and choice of speed." *IATSS Research* Vol. 22, No. 103-110.

Practical application projects for reference

Identification of brain regions associated with the central and peripheral visual field and applications for improving traffic safety: 164–167
An educational program for better control of emotions while driving: 168–171
A study on safety measures considering the psychological behavior characteristics of cyclists, from adolescents to the elderly: 172–175