Study on Driving Performance of Aged Drivers at the Intersections Compared with Young Drivers

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Abstract. In the recent aged society, the framework for assisting safe driving should be prepared with understanding the elderly driver's driving performance and their psychological features. The purpose of this study is aimed to obtain the fundamental data of aged driver for their effective assist-system. First, using driving simulator, aged people were observed their driving behaviors in various conditions at intersections compared with young drivers. These behaviors were measured in the condition of right and left turns and crossing. As the results, in particular, significantly slower approaches were observed on every occasion, and the unstable driving behaviors were examined. Next, on the field tests of real running in proving ground, the aged drivers were apt to run rapidly in the case of approaching the crossing compared with young drivers. These driving performances should be interfered with the traffic flow and exposed to the risk of accidents.

Keywords: Aged Driver, Driving Performance, Intersection.

1 Introduction

Aged is defined as people who are weakened the social role function and self-sustaining function, due to the weakening of physical and physiological and the changes of psychological. Currently, Japan distinguishes a super-aged society, over 22.1% of aged population, and Korea is categorized as an aging society, and is expected to become an aged society by 2019, according to the OECD report in 2010 (see Fig. 1). Therefore, it is required that much more support and assistance. In particular, the most important thing is security, which it is urgent to prepare comprehensive measures that will secure aged people' future. Safe driving assistance would be necessary for one of those things. Recently, aged driver's traffic accidents increased as taking part in various activities. It is a complex and continuous behavior that driving is concerning with the internal and the external situation, and then the behavior quickly and accurately determined (operation) and also to perform repetitive tasks given by approach implicit in a kind of the unconscious memory (implicit memory), according to previous experience. However, the aged who physical function reduced and mental and psychological changed has difficulty while driving.

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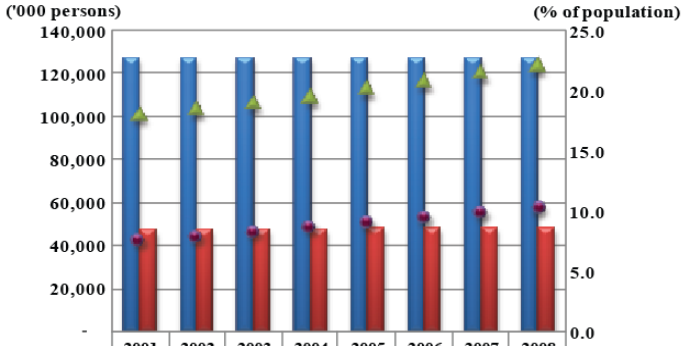
Previous studies suggested that they were significant decreases in their ability to split their attention compared with the young driver and rapidly decreased judgments in the event of accidents[1], caused an accident with a high accidental rate per distance traveled, due to they could not appropriate responses[2]. In particular, it is an important issue to be resolved to being involved the fatalities because of weakened physical performance. The development of driver assistance systems for aged drivers to support is urgent. However, appropriate support systems for the aged are few, despite of the development and commercialization. Therefore, it is necessary to characterize the driving behavior and to estimate their internal factors.



	2001	2002	2003	2004	2005	2006	2007	2008
total population of Japan ('000 persons)	127,29	127,43	127,61	127,68	127,76	127,77	127,77	127,56
total population of Korea ('000 persons)	47,357	47,622	47,859	48,039	48,138	48,297	48,456	48,607
aged population aged 65 and over of Japan (% of population)	18	18.5	19	19.5	20.2	20.8	21.5	22.1
aged population aged 65 and over of Korea (% of population)	7.6	7.9	8.3	8.7	9.1	9.5	9.9	10.3

Fig. 1. Total population and Aged population in Korea and Japan

2 Experiment 1

2.1 Methods

Laboratory Environment and Equipment. Driving simulator was designed and display devices were described the frontal scene as same as those of a real vehicle. The information for driving (front, left and right side) provides with LDC 32" monitor attached to the three sides. The environment of the laboratory was controlled. Room temperature was kept 22°and when a simulator was driven, 50dB noise was presented, which was slightly higher than 40dB noise of the common room. (see Fig.2.)

Participants. Subjects were 11 male young drivers, who were 20~30 years old, and 11 aged drivers, who were more than 65 years old. All of them had more than 1 year driving experience. Among them, three old adults dropped out of the test due to Gsimulator sickness, and the data obtained from them were excluded. The average age of participants were 24.2(±3.28), and 73.4(±4.58), respectively, and they had a normal or corrected eyesight with which they had no trouble in perceiving the stimulus presented on the monitor.

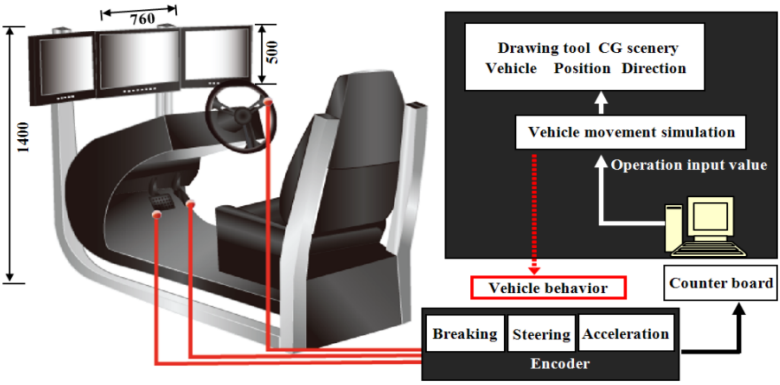


Fig. 2. Driving simulator(GDS-300S, Gridspace Co.)

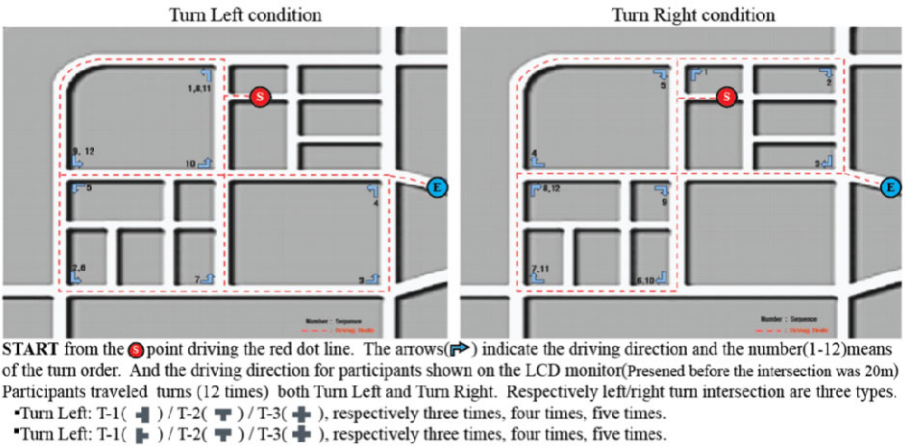


Fig. 3. Driving directions and Order of configurations

Procedure. Before conducting the test, they conducted the practice driving for about 3 minutes in order to adapt to driving simulator. The test consisted of left and right turn conditions of intersection, and the order of the test was counter balanced according to the participants of the test. In 10 min driving scenario which consisted of one - way 2 lanes, the left turn condition was that a driver turned left according to the

instruction of direction at the cross intersection and T intersection (No light), and the right turn condition was that a driver turned right according to the instruction of direction like the left turn condition(see Fig. 3.).

Also, by each condition, it consisted of 12 turns, that is, 12 times of conduction. We received data, the accelerator control, brake control, steering from the DS during the experiments. Then to examine the difference of driving according to turn types (left and right turn) at the intersection and age (young and old), 2 * 2 Mixed ANOVA by applying mixed factors design were conducted, in which turn types and age were independent variables and the measures of driving performance were variables.

And then, to examine the difference of driving according to turn types (left and right turn) at the intersection and age (young and old), 2 * 2 Mixed ANOVA by applying mixed factors design were conducted, in which turn types and age were independent variables and the measures of driving performance (approach velocity at the intersection, the passing time at the intersection, the speed when passing the intersection, and handling deviation) were variables.

2.2 Results

Approach Velocity at the Intersection. As a result, there were difference in approach velocity at the intersection, according to turn type and age. In left turn, the main effect of according to age was significant (see Fig. 4) [**p=.000]. But the main effect of according to intersection type (T-1, T-2, T-3) and interaction effect were not significant, respectively [p=.230] and [p=.918]. And in right turn, the main effect according to age [**p=.000] and intersection type [* p=.030] were significant. Also interaction was not significant. Young drivers(Mean of Left Turn =26.194, Right Turn=27.496) approached the intersection faster than aged drivers (Left Turn Mean=17.097, Right Turn=18.442).

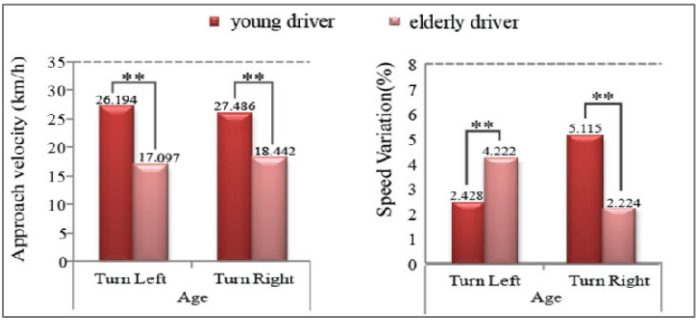


Fig. 4. Approach velocity(left) and Speed variation(right), [*p<.05, **p<.01]

Passing Time. As for passing time, in turn left, the main effect of both age [**p=.000] and intersection types [**p=.000] were significant (see Fig. 5). Also, in turn right, the main effect of both age [**p=.001] and intersection types [**p=.000] were significant. However, in right turn section, the passing time of young drivers was significantly longer than that of aged drivers[**p=.001], In right turn section, the difference of the passing time between two age groups was 1.082s, while in left turn section, that was 4.693s. But all of the interaction effect was not significant. Therefore, the analysis of simple main effect was conducted according to age and turn type. As a result, both left and right turn section were significant, respectively[**p=.001] [**p=.001].

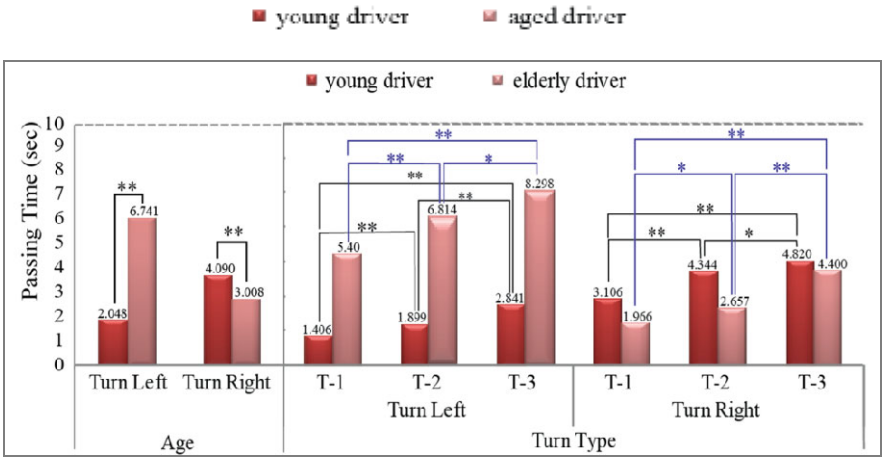


Fig. 5. Passing time thought the intersections (*p<.05, **p<.01).

Speed Variation While Passing Through the Intersection. For speed variation while passing the intersection, as a result of analyzing according to turn types and age, the main effect of both was significant. The speed variation of aged drivers were significantly larger than that of young driver [**p=.004] in turn left section. However, in turn right section, young driver' was larger (see. Fig. 4).

3 Experiment 2

In this experiment, on the field tests of real running in proving ground, the details of aged driver's behaviors were classified according to the process of entering intersections, namely recognizing the crossing and operating the braking. The surroundings of the intersections like stop signs and fences were settled according to experimental conditions in the study. Aged driver's reduced visual acuity was also considered.

3.1 Method

Environment and Equipment. Experiment 2 was conducted with a driver's license center in Kagawa, Japan. Small car (engine bore volume 1,000cc) has been used. The four cameras were installed in the car. These were used to record driving forward scene, changes of the speedometer, driver's facial scene and a brake pedal behaviors, respectively. Light sensor was installed to detect whether the brake operation.

Participants. Young people who has the usual driving experiance, especially students without problems in 10 participants (men 7, women 3, 22.3-24.0 years, mean age 23 years) and aged people were selected though screening tests (listening survey of personal information, visual acuity, color vision test. MMSE) 10 participants (male 5, female 5, 69-78 years old, mean age 70 years) were take part in the experiment.

Procedure and stimuli. Before conducting the test, they had the practice driving for about 10 minutes in order to adapt to driving ground. Each task was composed 12 times to pass the intersection, namely 4 times trials for three kinds of intersection A,B and C. The experimental time was approximately 20 minutes. Each intersection was composed 6 types according to barrier fences and stop signs (see Fig. 6). The situation of six kinds was provided, according to fences and signs. The fence classified ahead vision, named Easy to view and Difficult to view. And the sign classified to none, general, prominence by installing LED, respectively named No Sign, Typical Sign, and Shining Sign.

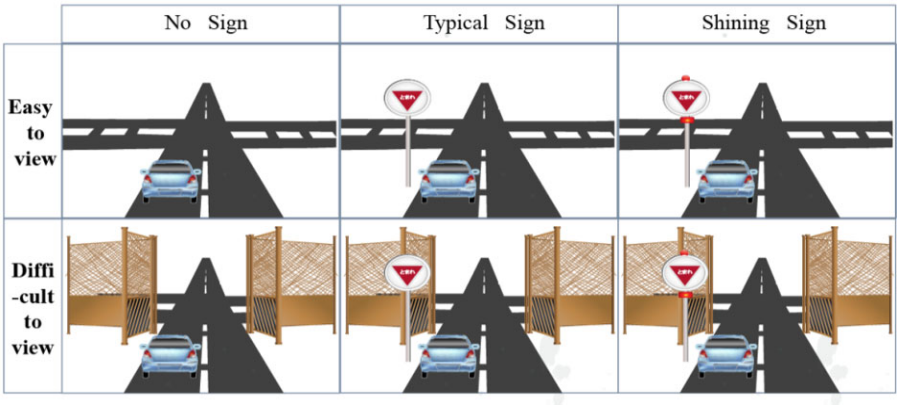


Fig. 6. The six kinds of environment at intersection

These items are measured for every participant in entering the intersections, as followings (see Fig.7).

1. Vo [Km/h]: Velocity at the deceleration onset.
2. Tp[s]: Time from operating brake until of the minimum speed.

3. Lo[m] : Distance from minimum speed position to stop line
4. Jerk [m/s^3]: Rate of acceleration change j from brake operation. a : acceleration v : velocity, r : position

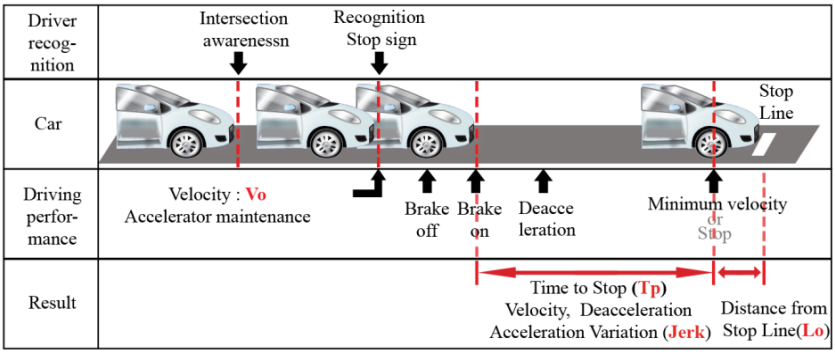


Fig. 7. Measuring of Stop and braking behaviors

3.2 Results

Driving Behaviors While Approach at the Intersection (Fig.8).

- Velocity of the Deceleration onset; Vo[km/h]: Vo of aged driver drivers was faster than that of young drivers in all intersection.
- Time from brake initiation to minimum speed; Tp[s]: Tp of young driver drivers was measured as longer than that of aged drivers in all intersection.
- Distance from minimum speed position to stop line; Lo[m]: Lo of aged driver was farther than that of young drivers' Lo in all intersection.
- Rate of acceleration change from brake operation; Jerk [m/s^3]: Jerk of aged driver was lager then young driver both *Jmin* and *Jmax* in intersection.

Stop According to the Visibility by Stop Sign and Barrier Fence

The variables were classified as four-kinds according to stop behavior and stop consciousness.

- Completely stop: velocity 0
- Willingness to stop: velocity $\neq$ 0. There was braking.
- Unknown willingness to stop: velocity $\neq$ 0. There was not both braking and acceleration behavior and affected in the ahead road
- Completely none stop: velocity $\neq$ 0. There was nothing.

As a result, the percentage of complete stop, willingness to stop, unknown willingness to stop, completely none stop are shown in Table.1. Regardless of age, the completely none stop occupied large percentage in the condition of no sign. Overall,

the young drivers increased the rate completely stop compared with aged driver. In addition, the noticeable degree of the conditions sign tended to increase the rate stop regardless of fence. Young drivers were no completely missing where stop sign installed intersections. Fig. 9 shows the percentage of completely stop and none completely stop. Also, completely stop was larger in shining-sign conditions and easy-to view conditions compared with no-sign conditions and difficult-to-view.

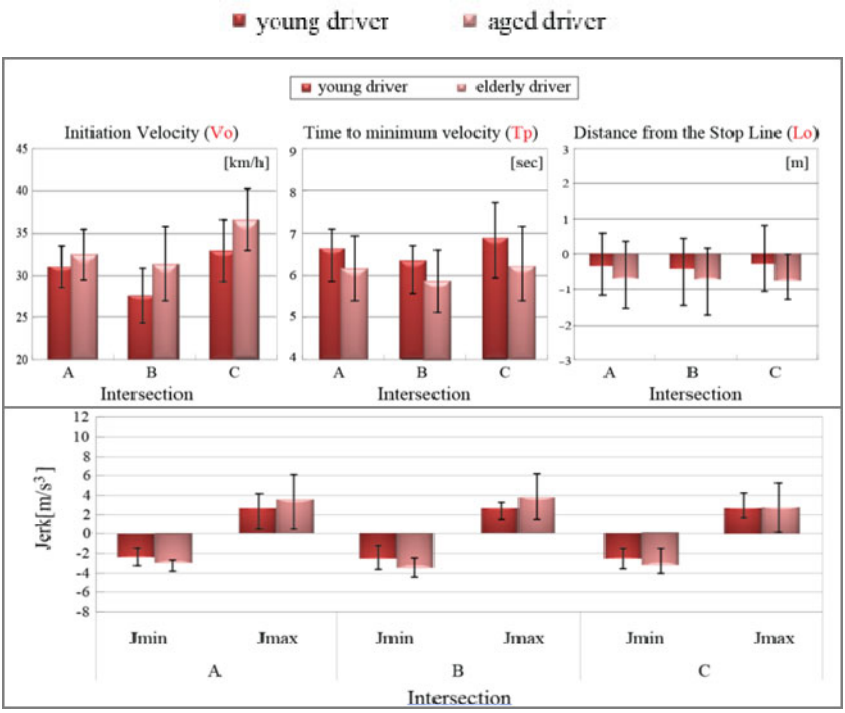


Fig. 8. Comparison of the measured performance (Vo, Tp, Lo and Jerk at the intersection)

Table 1. Percentage according to conditions by sign and fence

			Visual Interruption Factors (%)			
			young diver		aged driver	
		(%)	Difficult to View	Easy to View	Difficult to View	Easy to View
Sign visibility	No Sign	Completely Stop	0	3	0	3
		Willingless to Stop	48	59	57	39
		Unknown Willingless to Stop	16	0	19	8
		None Completely stop	36	38	24	50
	Typical Sign	Completely Stop	40.5	25	13	20
		Willingless to Stop	59.5	75	78	70
		Unknown Willingless to Stop	0	0	6	0
		None Completely stop	0	0	3	10
	Shining Sign	Completely Stop	63	53	43	40
		Willingless to Stop	27	47	45	56
		Unknown Willingless to Stop	0	0	0	2
		None Completely stop	0	0	12	2

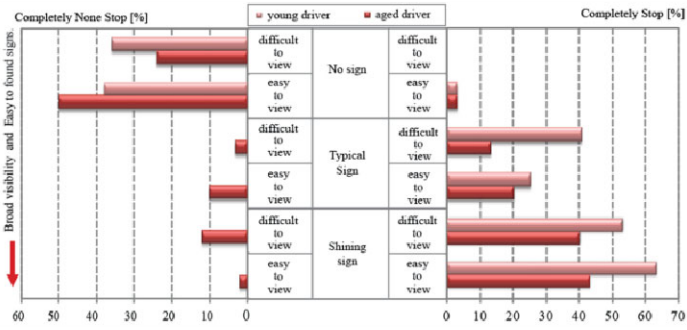


Fig. 9. The rate of completely-stop and none-completely-stop according to age.

Table 2. Database about the aged drivers braking behaviors features

Older adults braking behaviors feature		Over Speed, Unintended acceleration	Abrupt operations, Abrupt deceleration and stop	Jerk large operations Lack of politeness	Position stop inadequate, Decreased visual acuity in the sense of the vehicle
Database Important (infrastructure, education)	Appro - aches	Improve of hazard prediction capabilities	Improve of the operating margin capabilities	Improve ofsmooth operation and awareness	Stop position for easy found
	Measures	Displayed by the specific risk notification (Notice)	Prediction Training of Braking function	Education of vehicle movement with easy to book	Signs devise
Individual Differences (Careful vehicle, Device)	Appro - aches	Support to appropriate rate proposal	Support to smooth deceleration operation	Support to delicate operation	Support to assist with visual impairment
	Measures	Attention induction by Sound and video	Brake assist softly	Pedal operation Profile control	The visual system looks right at stop position

4 Discussion and Conclusion

The purpose of this study was to discuss driving behaviors including turns and straight running at the intersection. Experiments were conducted two times. In Experiment 1, using driving simulator, driving behaviors were measured approaching and passing at intersections without traffic signals based on turn left and turn right classified depending on the type of intersection.

As a result, the aged drivers were slower compared to young driver in the approach velocity at the intersection. However, a significant difference according to the intersection type was not examined. As to the passing time in the intersection, aged drivers were much slower than young drivers, as 6.7 sec and 2.0 sec on turn left. On the other hand, they (4.1 sec) were rather faster compared to 3.0 seconds of young driver. Moreover the simple main effects analysis showed significantly slower both turn left condition and turn right condition at the intersection in orderT-1, T-2, T-3. Next speed variations were measured while through the intersection. The results showed that the variation of the aged drivers were significantly larger in the turn left condition [** p =. 004] and significantly lowers than the young drivers in turn right condition [** p =. 000].

Yeoh Sok Foon (2009) conducted to collect information about driving related practices, knowledge, attitude and confidence of the aged drivers. The results showed that aged drivers who had higher level of self-rated confidence were reflecting higher level of driving ability. However, the response of confidence level score (not confident, somewhat confident, very confident) in many driving situation showed that 83 aged people (20.8%) responded the most difficult not-confident when they do turn right at an intersection without a traffic signal (right-hand; this study indicates left turn, as left-hand) [3]. Aged drives to compensate for the weakening of driving function due to the physical loss, and they show driving behavior avoiding a road where there is much traffic and time zone(rush-hour, etc.) when there is much traffic [4]. In our experiments, Yeoh Sok Foon (2009) the collection research has been experimentally proved, supporting their research. Driving directions before 20m to enter the intersection were indicated by arrows in display the top center, as. So, aged drivers accessed significantly slower at the intersection, because they predict the intersection in advance. They showed very large variations while left turn speed approaching at the intersection. It seems unstable the brake pedal operation. So, they found driving at a lower speed, as slow through the intersection. In particular, these driving behavior more definitely has shown according to T1 (each, type) than T2 (type), T3 (type) many more traffic flow, there are a lot of information. That is can be explained aged drivers were slower under a pressure before of approach at the intersection without traffic signal. This hesitant behavior in the intersection rather than prevent traffic flow or interfere with other driver's course, which has greatly the risk of accidents.

Also, we conducted the experiment 2. The actual driving was executed in the course of driver's license training center. Driving directions toward the driver were indicated by the operator of the back seat, so the driver could not predict the location of intersection. In these conditions the direction of running consists only of straight at the intersection. In order to consider visibility and driving attention to the environments, experimental condition was composed several traffic situation by different stop signs and barrier fences. Then, we observed the driving behaviors. As a result, aged drivers traveled much faster than young driver just before detection of the intersections. If they find an intersection they could slow dramatically. They cannot predict the intersection while driving. Then if they detect, the behavior would be a sudden braking. These results can be explained due to the weakness of their vision. They had also a tendency to stop away from the stop line, as a cause of degradation cognitive ability.

In the results by installation of the sign and fence, stop pass percentage was more frequent in the condition of easy-to-view both young and aged drivers. Another completely stop at intersections has increased the rate as easy to detect the signs these results particularly were noticeable from the aged. Their speed was very fast, 40km/h, in the condition of easy-to-view when through the intersection. This can be explained that aged drivers drive careless and determined and sure driving ability. But driving around the environment (time of day, traffic flow, etc.), there are very many factors. Their decision is likely to be an error, as the degenerations of a dynamic

vision and the distance vision to measure in front of the object, cognitive ability, also physical reflexes backwards or stuff in their ability to respond to unexpected situations. That led to a fatal accident.

In these experiments, we discussed the variable about the driving performance of comparing aged drivers and young drivers when approach and pass the intersection. The results show that aged driver were very confident in driving and very careless driving when they are convinced the situation of ahead as visually. However, they bring to pressure at the left turn showed the slow and hesitant driving behavior, which prevent the traffic flow and can cause confusion for other drivers. In experiment 2 suggests that they given some of driving stimulus (support) could be improved, based on increasing the rates of stop according to the condition on sign. So, it is urgently needed considering the aged characteristics. According to these results, the basic database of the aged driving characteristics was verified to establish the effective driving support system.

In this study, there were limitations to be conducted in that the DS experiments in South Korea (Left Handle) and the real driving test in Japan (right handle). But the results is considered that would be used as a very important to study the aged support system in the future.

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