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Variation of Driving Skill among Elderly Drivers Compared to Young Drivers in Japan

Variasi Kemampuan Mengemudi pada Pengemudi Lanjut Usia Dibandingkan dengan Pengemudi Muda di Jepang

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Abstract

This study analyzed driving skill among Japanese elderly drivers compared to young drivers and see which less skilled that might impact road accident risk in highway. Subjects included young and elderly drivers, consisting of 10 college students (20 – 24 years old) and 25 elderly drivers (14 men and 11 women) coming from The Silver Manpower Centre, an organization for elderly > 60 years. Elderly drivers were divided into two age groups, namely elderly 1 aged 60 – 65 years (10 persons) and elderly 2 aged > 65 years (15 persons). Driving performance was evaluated by using driving game simulator in laboratory. Analysis was conducted on consistency in the lane, lane-changing skill, traffic sign compliance, right-turning skill, braking and driving speed. Statistical analysis was performed using ANOVA test. Generally, performance of elderly 2 was lower than the young almost in all parameters including consistency in the lane (p value < 0.007), traffic sign compliance (p value < 0.011), right-turning skill (p value < 0.001) and braking (p value < 0.001). In the lane-changing skill, young drivers showed significantly higher score (p value < 0.007) than both elderly groups in which elderly 1 (p value < 0.004); elderly 2 (p value < 0.001). The group > 65 years old were likely to be wrong on seeing traffic signs due to visual limitation and long response of compliance.

Keywords: Driving skill, elderly drivers, young drivers

Abstrak

Penelitian ini menganalisis kemampuan mengemudi pada pengemudi lanjut usia (lansia) dibandingkan dengan usia muda di Jepang dan melihat keterampilan mengemudi yang kurang sehingga dapat memengaruhi risiko kecelakaan di jalan raya. Subjek penelitian adalah pengemudi usia muda dan lansia, terdiri dari 10 mahasiswa (20 - 24 tahun) dan 25 pengemudi lansia (14 laki-laki dan 11 perempuan) berasal dari The Silver Menpower Center, organisasi bagi lansia > 60 tahun. Pengemudi lansia dibagi menjadi dua kelompok, yaitu lansia 1 berusia 60 - 65 tahun (10 orang) dan lansia 2 berusia > 65 tahun (15 orang). Kemampuan mengemudi dievaluasi dengan simulator permainan mengemudi dalam laboratorium. Analisis dilakukan pada konsistensi dalam jalur, perubahan jalur, kepatuhan pada rambu lalu lintas, kemampuan berbalik kanan, mengerem/akselerasi, dan kecepatan mengemudi. Analisis statistik menggunakan uji ANOVA. Secara umum, kemampuan pengemudi lansia 2 lebih rendah dibandingkan usia muda hampir di semua parameter, meliputi kekonsistenan dalam jalur (nilai p < 0,007), kepatuhan pada rambu lalu lintas (nilai p < 0,011), kemampuan berbalik kanan (nilai p < 0,001), dan keterampilan mengerem/akselerasi (nilai p < 0,001). Dalam keterampilan mengubah jalur, pengemudi usia muda menunjukkan skor signifikan (nilai p < 0,007) lebih tinggi dari kedua kelompok pengemudi lansia dimana lansia 1 (nilai p < 0,004); lansia 2 (nilai p < 0,001). Pengemudi > 65 tahun cenderung salah dalam melihat rambu lalu lintas karena terbatasnya penglihatan dan lamanya respons dalam mematuhinya.

Kata kunci: Kemampuan mengemudi, pengemudi lanjut usia, pengemudi muda

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Introduction

Driving is a complex task involving integration of visual, cognitive, and physical motor skills. Driving is important for maintaining independence, and driving cessation is linked to isolation, depression, and associated with functional impairment on older people. However, elderly drivers are at a higher risk of road accident because they have limitations in visual, cognitive and motoric skills. Driver deaths per crash involvement as fragility sign remains fairly stable, then started to increase steadily at the age of 60 years among men and women, with a steep increase at the age of 80 years or older. The relative risk for older male driver is about 2.2 times and 1.8 times for older female driver than younger driver.[1] Older drivers, with or without visual impairment, are rated as being less safe than younger and middle-aged drivers with normal vision.[2] In other words, elderly drivers have a higher risk of road accident than young drivers.

The characteristics of elderly drivers on ordinary roads include drive slowly; keep longer than normal distance from drivers in front of them; tend to bear more to the left within their driving lane; have a tendency to drive in the outer lane; and tend to be unstable while driving in a junction that is when encountering merging traffic patterns.[3] The characteristics tend to increase the risks of road accidents for elderly drivers, which are on the rise.

Some references contend, however, that elderly drivers' performance is not always worse than young drivers. In general, the older subjects' performance do not differ from that of their younger counterparts except when the single- or dual-task involves routine modification in car-following.[4] It showed in the previous study that an unexpected result was that young drivers had significantly higher fatigue proneness scores than older drivers aged older than 65 years. It also found lower thrill seeking scores in elderly drivers due to elderly drivers' driving-routines that were typically shorter in both time and distance than younger drivers' routines.[5] The previous study which involved 10,856 elderly drivers as subjects in 35 prefectures across Japan also revealed that elderly drivers had short time in driving.[6] Approximately, 75% of them drove less than one hour per driving instance for daily activities, and almost 90% drove in express ways a few or no times per year. However, these presumably risk-lessening facts did not translate into a lower road accident risk for elderly drivers. In line with data of this study, there was also found an inconsistent relation between distance driven per year and crash rates called as 'low mileage bias', such that older drivers driving fewer kilometers per year were less safe than other drivers driving much higher times and distances.[7,8] Indeed, older drivers still have a higher risk of road accident than young drivers.

Driving performance was used as the outcome measure rather than crash rates because it provides objective assessment obtained under real world driving conditions. State records are subject to biases because crashes are not recorded if police do not attend the accident scene and there are differences in the type of information recorded between jurisdictions. In addition, if crash record was collected by self-assessment, so there was also recall bias and the slightly number of accidents among the elderly.

Drivers' skill should be tested by driving on the road or on circuits like those used for driver's license examinations. However, as safety, time, and economic factors given, the test can also be done in a laboratory room. Driving simulator can provide a safe, economical, and viable alternative to assess the driving performance of elderly drivers.[9] Moreover, it can be used as initial screening, in which recommendations for further driving assessment can be prescribed for those problematic or unsafe elderly drivers. Therefore, this study aimed to analyze elderly drivers' performance with parameters including maintaining lanes, lane changing, traffic sign compliance, right-turning skill, braking/acceleration and driving speed as well as to see which less skilled that could impact their road accident risk by using driving simulator then compared the results to the younger drivers.

Method

Subjects included Japanese young and elderly drivers. Ten young subjects were college students (5 males and 5 females), aged 20 – 24 years (= 22.4$\pm$1.35). As many as 25 elderly subjects (14 males and 11 females) came from the Silver Manpower Centre, an organization for people older than 60 years old. The elderly subjects were divided into two groups of age, namely elderly 1 aged 60 – 65 years old (10 persons, 5 males and 5 females, = 62.8$\pm$ 1.48), and elderly 2 aged older than 65 years old (15 persons, 8 males and 7 females, 66 – 77 years old, = 70.33 $\pm$ 3.11).

Elderly drivers were grouped by age in consideration of the United Nations (UN) "Population Aging Report" (2009), which presented evidence that today's 60-year-olds are often very different from their parents at the same age. The use of such aging indicators is often justified on the grounds that these fixed ages (60, 65 or 80 years depending on the study) correspond to the ages of eligibility for certain social programs, such as pension systems benefits. Elderly drivers aged 65 – 89 years made significantly more at-fault safety errors during multitasking than middle-aged drivers.[10] Therefore, based on UN categorized and safety risk of elderly drivers, this study divided elderly groups starting at the age of 60 years and 65 years or older.

Driving performance was evaluated through a driving game simulator in a laboratory room. The driving game

Figure 1. Driving Simulator Game in Laboratory

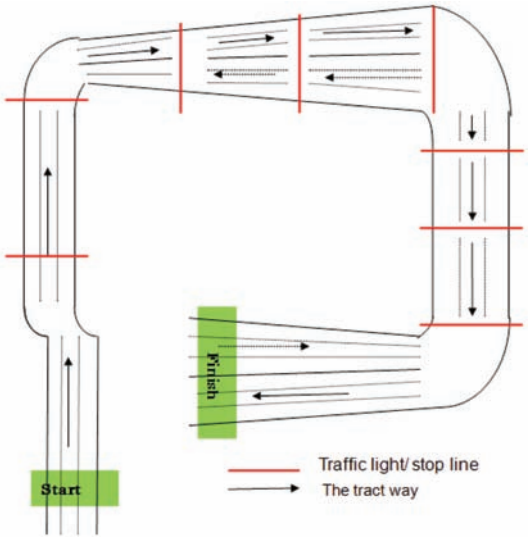

Figure 2. Driver's Skill Test Track

simulator was shown in Figure 1. The luminance level in the experiment room was 270 – 300 lx for measures at the Liquid Crystal Display (LCD) of 46 inch, and the room temperature was 23ºC with 50% relative humidity.

The track was simulated city road in Japan, specifically, in the Shinjuku area of Tokyo where drivers must bear to left side of the road. The track was shown in Figure 2, which consisted of eight traffic lights/stop lines (red line) requiring participants to stop properly as a response. The track started as one-way and consisted of three lanes. After a right turn on, there were two way roads of four or six lanes, and then it changed again to a one way road with three lanes after a right turn. The last track had no traffic light/stop line. The subjects were required to drive at a speed of 40 – 60 km/h and were not to go over the maximum speed of 60 km/h.

After subjects were instructed about the track, they were allowed to try the track out until they were ready to start their skill performance test. Subjects then had to run the track for five laps.

The six parameters measured were maintaining lane position, lane change/deviation, traffic sign compliance, right-turning skill, braking/acceleration, and driving speed (Table 1). All parameters were evaluated as scores for driving safety criteria on a 10-point scale based on driver licensing standards.[8] There were score 1 – 3 as critical error (instructor had to take action); score 4 – 5 as poor driving and observation skills; score 6 – 8 as an average driving skills but with some bad habits and 9 – 10 as good to excellent driving and observational skill.

The assessment by filling out the assessment form was conducted. Initially, all parameters were worth a maximum score of 10. Then, during the driver's performance test, if subjects made one mistake, they would receive -1 and so forth continuously until the test was over. The final score was obtained by deducting the sum total of the minuses received per parameter from the maximum of 10. The same assessment procedure applied for each of the five laps.

First assessment was maintaining lane on a straight stretch of road where subjects were asked to always drive in the second lane from the left throughout the whole track. This measured how the subjects maintained the center of the lane, particularly on a straight stretch of road. Second assessment was lane-change deviation, and lane-changing skill was assessed from a one-way stretch of road to a two-way stretch or from four to six lanes. It measured the deviation when they had changed the lanes. Third assessment was traffic sign/signal compliance where subjects were assessed for traffic sign/signal compliance for signs/signals, such as traffic light, stop line, and stop sign. There were eight traffic signs/signals on the track and subjects had to react properly when passing those signs/signals. Right-turning skill required assessment for right turn maneuvering before and through T junctions. Turns should not be too wide and drivers must continue to follow the lane, maintaining a relatively stable speed, while braking/acceleration required assessment on how they control the accelerator and brake pedals. Subjects had to maintain speed between 40 km/h and 60 km/h. Last assessment was driving speed where subjects were assessed for driving speed. Subjects should not go over the maximum speed of 60 km/h. After collecting data and information about assessment of parameters, then its was analyzed by using SPSS, Version 20.0 by ANOVA.

Results

Table 1 and Figure 3 showed that the scores of young drivers were significantly higher than those of their seniors (elderly 2) almost in all parameters including maintaining lanes (p value < 0.007), traffic sign compliance (p value < 0.011), right-turning skill (p value < 0.001), and

Table 1. Anova Test Results

Driver's Skill Performance	Comparison of Age Groups		SE	F	Sig	95% CI	
						Lower Bound	Upper Bound
Maintaining lane position	Young	Elderly 1	0.408	1.084	0.128	-0.170	1.890
		Elderly 2	0.372		0.007*	0.289	2.169
Lane-changing deviation	Young	Elderly 1	0.423	5.478	0.004*	0.635	2.925
		Elderly 2	0.279		0.001*	1.409	2.817
Traffic sign/signal compliance	Young	Elderly 1	0.467	8.675	0.399	-0.460	1.900
		Elderly 2	0.426		0.011*	0.254	2.409
Right-turning skill	Young	Elderly 1	0.519	1.785	0.084	-0.165	2.685
		Elderly 2	0.364		0.001*	0.910	2.777
Braking/acceleration	Young	Elderly 1	0.307	2.292	0.075	-0.071	1.551
		Elderly 2	0.430		0.001*	0.774	2.982
Driving speed	Young	Elderly 1	0.592	5.355	1.000	-1.656	1.336
		Elderly 2	0.541		1.000	-1.099	1.633
Time of experiment	Young	Elderly 1	13.340	6.953	0.001*	-96.198	27.722
		Elderly 2	15.051		0.001*	-192.449	-111.648

Note: *have significant difference with CI=95%

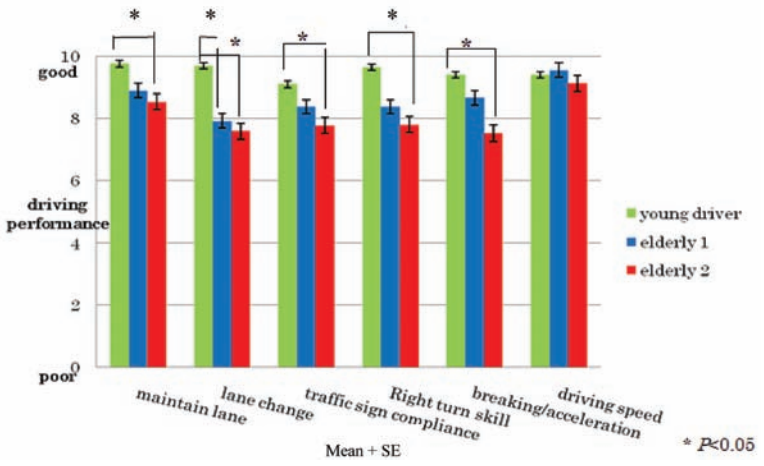

Figure 3. Each Score of Driving Skill Performance between Young and Elderly Drivers

braking/acceleration skill ($p < 0.001$). In the lane-changing skill, young drivers showed significantly higher scores than both groups of elderly drivers, which is elderly 1 (p value < 0.004); elderly 2 (p value < 0.001). On the other hand, there was no significant different found in term of driving speed between young and elderly drivers.

Young drivers needed less time than older drivers to finish the driving skill performance test. This represented a significant difference between young drivers and both groups of elderly drivers (p value < 0.001) (Figure 4).

Discussion

Although this study was carefully prepared, there were some limitations that need to be acknowledged and addressed. The driver's skill performance test was conducted by means of a driving simulator in a laboratory rather than an actual driving situation. The immediate problem was that subjects had to become familiar with the simulator technology before the test began. Younger drivers were accustomed to this kind of technology, while this was not the case with older drivers. Although all subjects were afforded practice time before taking the test, handling the simulator steering wheel turned out to be a problem, especially for elderly drivers. Young drivers only needed 10 minutes to practice while their counterparts needed $\pm$1 hour to get accustomed to the technology before taking the test. Nevertheless, final results showed that almost all scores were significantly higher for young drivers as compared to elderly drivers.

Since the number of lanes on the simulated road was not always the same, driver's performance in maintaining lane parameter was affected as this parameter measured the driver's ability to keep his/her car central to the same lane as he/she proceeded along the simulated course. In order to minimize the amount of deviation when lane numbers changed along the course, or when it changed from a one-way to two-way pattern, another driver's skill performance parameter was added to cover lane chang-

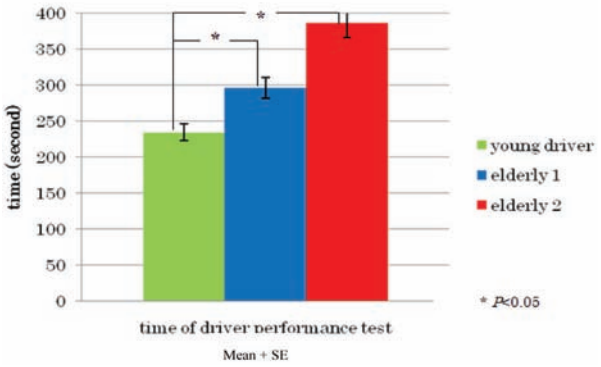

Figure 4. Time of Driver's Performance Test between Young and Elderly Drivers

ing. This study found that elderly drivers were frequently out of lane, confused of traffic signs/signals, and responded late in maintaining lanes as lane and traffic patterns changed. This result confirmed with characteristics of elderly drivers on road. It defined elderly drivers tend to bear more to the left within their driving lane and they tend to drive in the outer lane.

This poor performance in maintaining lane and lane changing parameters among elderly drivers was caused by their lower visual abilities and cognitive difficulty in judging, and responding to the change in road conditions. This study confirmed the finding reporting that young (18-25 years) and middle-aged drivers (26-64 years) made significantly more correct decisions performance in intersection than did young-old (65-73 years) and old-old (74+ years) drivers. Older drivers had especially low accuracy scores and failure to detect the pedestrians that might have led to decide the intersection was clear and the turn maneuver was safe to complete. Besides, it also found older participants tend to miss relevant vehicles that were relatively large and conspicuous (visual angles = 2.23° x 1.97° and 4.2° x 2.25°).[11] Executing a maneuver that requires precise tracking of vehicle position (e.g., turning or merging) in the presence of potential conflicts (e.g., a pedestrian crossing the intersection) is dependent on the driver's ability to divide attention effectively.[12]

In order to measure driver's skill performance in traffic sign/signal compliance, this study required each subject to stop properly behind the stop line eight times in which there were eight traffic lights/stop signs each lap. Accordingly, since there were five laps, they had to stop 40 times. However, elderly drivers often had difficulties in seeing and recognizing traffic signs correctly. Consequently, since they were instructed to strictly obey a sign/signal, they had to make a sudden stop (about 1.5 times) for their inability to respond within the normal flow of driving. Some subjects even had to back up their simulated vehicles (about 3.5 times) because they went over the stop line or stop signs at the intersection. This condition confirmed the interactions between visual (traffic sign/signal awareness), cognitive (processing information requiring subjects to make a stop), and motor skills (decreasing the speed and pushing the brake pedals smoothly).

The previous study confirmed the result of UFOV for elderly drivers older than 65 years had prolonged reaction for color and shape stimuli and this has caused many no reaction errors.[13] The older drivers appeared to rely heavily on the traffic control devices (e.g., lights) in the intersection to make decisions, often to the exclusion of other important objects, such as pedestrians and vehicles. Both older and younger drivers used the traffic light as a basis for a turn decision, if one was present at the intersection. However, younger drivers appeared to scan additional locations in the images before making a turn decision.[11] Furthermore, elderly drivers were shown to have more difficulty seeing stimuli in the upper peripheral view, which contributed to traffic sign over-sighting.

As recognized during practice time, elderly drivers experienced difficulty in handling the driving simulator steering wheel that elderly drivers had the tendency to slow down in order to proceed carefully through the turn because the steering mechanism felt lighter than a real car's steering. However, in spite of their slow, careful approach, they still could not maintain lanes properly. This steering disparity was not a problem for the young drivers as their right-turning skill performance was good. However, by comparison, elderly drivers older than 65 years had significant under-scoring in right-turning skill only since this required higher steering control (Figure 3).

The other study also proved driver's skill performance rating including in terms of the steering operation when turning left and right; in the normal operation errors between the driving conditions with and without paced auditory serial addition test (PASAT) were significantly different for the young aged and older group. This suggested that distraction during driving induced a lack of smoothness in the driving, resulting driving operation errors.[14] Besides, these differences between the young and elderly might be caused by differences of familiarity with driving simulators. The high transferability of observations was between simulated and on-road driving assessment.[9] Further enhancement of driving simulators is expected to make simulated driving more closely resemble real driving, which can make it a cost effective alternative to road testing.

Regarding braking and acceleration skills, the young drivers performed better than the elderly. Young drivers had smooth speed control at around 40 km/h. However, young drivers often operated over the maximum speed, so the time they needed to finish the driving skill performance test was significantly less than elderly subjects

(Figure 4). This tendency was also found in the previous study which reported that elderly drivers aged 55 – 65 years took longer in braking and stopping maneuvers.[15] Meanwhile, another study proved that the elderly (65 and 89 years old) drove slower and showed decreased speed variability during distraction compared to middle-aged drivers (40 and 64 years old).[10] They also tend to "freeze up", spending significantly more time holding the gas pedal steady. Erroneous stepping on the accelerator and brake pedals was one of the most common causes of accidents among elderly drivers. Therefore, an onboard alarm automatically triggered when vehicle acceleration increased too rapidly (or when accelerator pressure as compared to brake pedal pressure is too great) could be a good control on wrong pedal accidents.

Conclusion

In general, elderly drivers' skill performance is worse than the young drivers'. This is proven by significant differences between young and elderly drivers in almost all parameters, and also in line with the results of previous studies. However, this does not mean that young drivers have a consequentially low accident risk. Since the result of this study shows that elderly drivers have poorer driving performance than young drivers, it can be concluded that they are drivers at higher risk on the road. Still, traffic sign/signal oversight and prolonged response times in complying with these signs or signals are potential risk factors.

Recommendation

Based on the results, it is important to improve safety for elderly drivers since their all variation of performance is declining. Meanwhile, the extension of their driving license needs to be considered for test drive and vision test again. Mandatory in-person license renewal per year or the need to pass a vision test is associated with significant reductions in population-based fatal crash involvement rates for drivers aged 85 years and older.[14] Besides, it needs performance predictor-based cognitive measures to consider crash involvement among older drivers. High-risk older drivers can be identified through brief, performance-based measures as administered in Motor Vehicle Administration setting.[16] If they do not meet the requirements for renewal driver's license, so counseling and motivation need to be provided to avoid stress because they cannot drive anymore. Otherwise, if the elderly drivers are still allowed to drive, there should be special vehicle which can improve their attention, such as a warning system to reduce the speed before the stop signs or traffic lights.

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