International Journal of Industrial Ergonomics 54 (2016) 32–41

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Approaching and stopping behaviors to the intersections of aged drivers compared with young drivers

Seunghee Hong [a, *], Byungchan Min [c], Shunichi Doi [b], Keisuke Suzuki [b]

[a] Graduate School of Engineering, University of Kagawa, Kagawa, 761-0396, Japan
[b] Faculty of Engineering, University of Kagawa, Kagawa, 761-0396, Japan
[c] Industrial Management Engineering, Hanbat National University, Daejeon, 305-719, South Korea

ARTICLE INFO

Article history:
Received 21 January 2013
Received in revised form
10 December 2015
Accepted 24 December 2015
Available online 23 January 2016

Keywords:
Aged driver
Driving performance
Intersections

ABSTRACT

According to the many reports of the traffic accidents, the number of the accidents near the intersections was increased in the cases of the aged drivers. The purpose of the research was to measure the sensitivity of elder drivers through behavioral responses in approaching and stopping to the intersections and to obtain the difference of the responses for braking and stopping comparing with young drivers. In the field tests of real running on experimental proving ground, elder and young drivers were observed their driving behaviors in various conditions of approaching and stopping at intersections. Comparing the results of the elder with the young, the unstable driving behaviors were examined in elderly and they were apt to run fast in approaching the intersection and also stopping rapidly. The rates of deceleration change (Jerk) with braking operation were unstable and the driving behaviors were affected by the environments or conditions of the intersection. These driving performances should be interfered with the traffic flow and exposed to the risk of accidents. If the features of these aged driver's behaviors were clarified better, the more effective driving assistant systems for elderly could be developed based on characteristics of elderly driver's driving performances and their physical and psychological features of driving.

1. Introduction

Driving behaviors have been reported as a very complex task in sequential operations with the information of visual aspects among sensory aspects of a human. The many preceding studies suggested that the number of accidents near intersections occur frequently.

According to a report of Japan Metropolitan Police Department in 2014-1st half, traffic accidents occurred at intersection (28.0%) and at near intersections (24.1%) as shown in Fig. 1. Hence, regarding the types of traffic accidents occurred elderly drivers, the face to face accidents was 480 cases in total of 916 cases as shown in Fig. 2.

Past researchers examined the effects of attention failures at intersections on driving behaviors. Failures of drawing attention may result from the improper distribution of attention, difficulties of visual recognitions, and/or inappropriate selective attention. Therefore, if the visual ability of a driver is deteriorated and damaged (Hickson et al., 2010; Dukic and Broberg, 2014), he or she has to select the limited driving behavior or give up the driving (Marie Dit Asse et al., 2014). Considering these aspects, the behaviors of elderly drivers pertains to the important variable in driving behavior. When they selected an inappropriate timing on driving behaviors compared to younger drivers, they cause traffic accidents. Many studies reported that the physical ability of elderly drivers deteriorates, because of the limitation of visual function related aging influenced on driving behavior (Kazuya et al., 2010). Therefore, elderly drivers, who make wrong decisions in terms of braking timings (Lucidi et al., 2014) or the force putting a brake pedal due to severe deteriorations by ageing, cause traffic accidents (Green et al., 2013; Keay et al., 2013).

2. Experimental methods

In this study, the driving characteristics of elderly drivers during approaching and stopping to the intersections were investigated through field tests. The characteristics of driving performances between young drivers and elderly drivers were compared. A flow

* Corresponding author.
E-mail addresses: zeele22@naver.com (S. Hong), hsh.kagawa@gmail.com (K. Suzuki).

http://dx.doi.org/10.1016/j.ergon.2015.12.002
0169-8141/

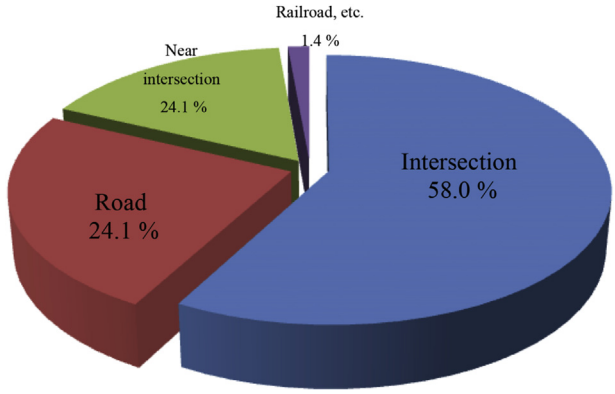

Fig. 1. The traffic accidents in 2014-1st half in termd of road types.

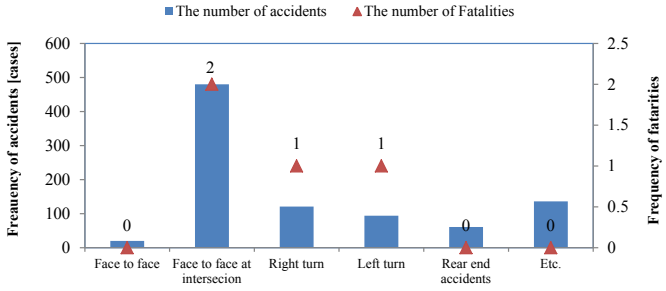

Fig. 2. The traffic accidents occurred by elderly drivers in 2014-1st half in termd of road types.

of the driving experiment is shown in Fig. 3.

I designed an experiment to investigate elderly drivers' driving characteristics at intersections, comparing with young drivers. At first, I needed to select physical and mental healthy elderly participants. Therefore, I recruited healthy elderly drivers through a local job center, and investigated physical and mental ability of elderly drivers. Next, the selected elderly drivers and young drivers joined the field driving tasks, and the driving tasks were evaluated and analyzed.

2.1. The experimental apparatus and the design of experimental intersections

2.1.1. Subjects of the experiment and selection of elderly drivers

Ten elderly drivers over 65 years old and ten young drivers were participated in the driving tasks. The young drivers (men; 7, women; 3, 22.3~24.0 years, mean age; 23 years) having more than one year of driving experience joined the experiment.

For selecting elderly persons having no trouble in driving, I asked a local job center to recruit healthy elderly participants. I recruited 45 elderly participants. At first, elderly drivers were joined a listening survey of personal information, a visual acuity test, a color vision test, Mini Mental State Examination (MMSE) and Usual Field of Visual (UFOV). The results of the test, I selected healthy 10 elderly drivers (males; 5, females; 5, 69~78 years).

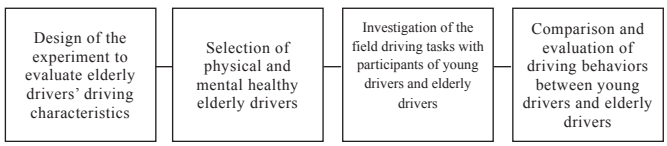

Fig. 3. Experiment process model to evaluate elderly drivers' driving characteristics at intersections.

2.1.2. Experimental vehicle

A car was used at the driving tasks. In this car, a GPS sensor, an optoelectronic switch, four cameras and computer devices were installed. The GPS sensor obtained data regarding the lateral and longitudinal velocity and the position of the car. The optoelectronic switch detected braking operations, and four cameras recorded a forward driving scene, a speed meter scene, a driver's facial scene and a brake pedal behavior scene as shown in Fig. 4. All these data was stored into a personal computer on the car.

2.1.3. Design of intersections and the experimental conditions

The experimental driving was conducted at a driver's license training ground with 230 m × 130 m in Kagawa prefecture of Japan as shown in Fig. 5.

Three intersections without traffic lights were selected, and separately designated as the intersection A, B and C. In order to set various intersection environments, stop signs, blind corners, rubber stop lines were set. Cameras and graduated rulers to measure stop were used as shown in Fig. 6.

Moreover, for evaluating the effect of environment of intersections on braking behaviors, six conditions using various features of stop signs and blind fences were designed as shown in Fig. 7. An ordinary stop sign and enhanced stop sign which has flashing red LED lamp were selected.

2.1.4. Experimental scenario

After participants rode on the experimental vehicle, the operator in the back seat briefly explained a role of the whole experiment. Then, they had a short driving to learn a sense on the road for 5 min, and returned to the starting point to begin this experiment. The experiments were made of the primary and secondary experiment, and each experiment passed all intersection A, B and C, each trial was carried out twice in 20 min. Numbers of passes of the intersection with the respective conditions are shown as follows in Table 1.

2.1.5. Evaluation methods of deceleration behaviors

Regarding the process of deceleration at intersections, parameters to evaluate driving behaviors were selected. Fig. 8 shows a sequential echogram in terms of deceleration and stopping behaviors near the intersection. The parameters are as follows:

The velocity at braking initiation: Vo [Km/h]
The time from braking initiation to stop: Tp [s]
The distance from stop position to a stop line: Lo[m]
The rate of deceleration change from braking operation: Jerk [m/s3]

3. The results of deceleration behaviors

Statistical methods were used and the statistical terminology was used in this study. There are defined here. (1) MS: the mean squares, (2) SEM: the standard deviation, (3) df: the degrees of freedom, (4) F: the F-ratio which cuts off various proportions of the distributions. This may be computed for different values of df1 and df2., (5) T: the T-ratio which cuts off various proportions of the distributions. This may be computed for values of df.,(6) p: prob, probability, sig., or sig. of F/T, (7) VIF: the Variance Inflation Factor by David, 1998.