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ANALYSIS ON LONG-TERM CHANGES OF DRIVING BEHAVIOR BY ELDERLY DRIVER

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Abstract

Recently in Japan, the occurrence of traffic accidents by elderly drivers has become a social problem. It has been reported that traffic accidents caused by elderly drivers are caused by decline of cognitive impairment and physical function due to aging. Aging also affects the driving behavior of the driver. Therefore, it is important to evaluate the long-term change of driving behavior. If the long-term change of the driving behavior can be evaluated, it can be used as a judgment for returning the driver's license by elderly drivers. However, there is no previous study that quantitatively evaluates the long-term change of driving behavior by elderly drivers. Therefore, in this study, we analyze the long-term change of driving behavior by elderly drivers. This analysis uses data collected by car insurance companies. This data records driving information (vehicle-speed, 3-axis acceleration, vehicle position, driving date) and cognitive ability by an elderly driver from the present to 3 years ago. The evaluation indicator of driving behavior used the occurrence ratio of sudden braking. The occurrence ratio of sudden braking was calculated for each elderly driver from the present to 3 years ago. In conclusion, it was cleared that the occurrence ratio of sudden braking by elderly drivers increases with aging. In particular, this secular change is remarkable for elderly driver who has low cognitive ability. Furthermore, it was shown that there is possibility to prevent elderly drivers from causing traffic accidents by monitoring their occurrence ratio of sudden braking.

Keywords: elderly driver, driving ability, cognitive impairment

1 Introduction

Recently in Japan, the number of traffic accidents caused by elderly drivers has become a social problem. It has been reported that traffic accidents caused by elderly drivers are caused by decline of cognitive impairment and physical ability due to aging. Our country, the driver need to renew your driver's license once every three years. In National Police Agency also conducts cognitive impairment tests and training for elderly drivers aged 70 and over when renewing their licenses. However, the cognitive impairment of elderly drivers changes daily, thus it is difficult to judge from the result of the cognitive test at the license renewal.

There are several previous studies about elderly drivers. Myers et al [1] focused on the relationship between driving tests and cognitive tests by elderly drivers. As a result, it was cleared that the results of the cognitive test and the driving ability are correlation. Wadley et al [2] and Griffith et al [3] performed driving experiments by an elderly driver of MCI. They focused on the driving behavior when going straight and it has shown the possibility of discriminating MCI using lane deviance, steering stability, and vehicle speed changes. In addition, Frittelli et al [4] showed that elderly drivers of MCI tend to less time to follow vehicles in front. Beratis eta [5] and Shino et al [6] focused on the driving behavior

when changing lanes. It was shown that when the cognitive impairment of elderly drivers declines, driving operations of lane change tend to be delayed. These analysis of elderly drivers and cognitive impairment has been performed from various perspectives. However, it has become clear that no previous studies have focused on long-term changes in driving behavior of eldery drivers. The reason is that it is difficult to evaluate long-term changes in their driving behavior.
In this study, we analyze the relationsips cognitive impairment and long-term changes in driving behavior of elderly drivers. Figure 1 shown a flow in this study. Chapter 2 explains the usage data. Chapter 3 describes the creation of analytical data.Chapter 4 analyzes cognitive function and driving ability evaluation. Chapter 5 analyzes a long-term analysis of driving behavior. Finally, Chapter 6 concludes this analysis. The knowledge obtained from this analysis can be used for enlightenment to stop driving. In addition, it can contribute to the prevention of traffic accidents.

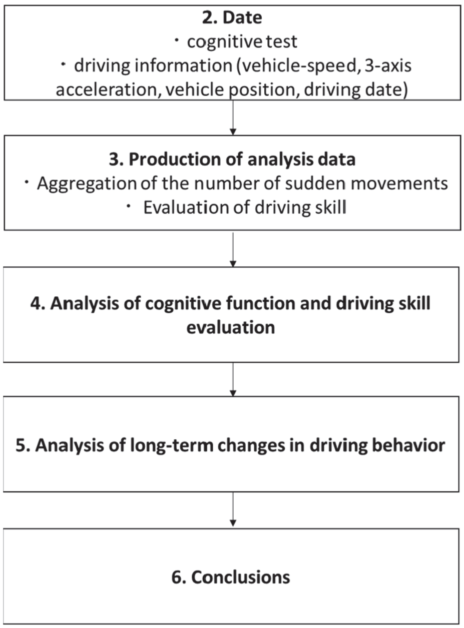

Figure 1 Research flow

2 Data

2.1 Participants

In this study, we analyzed 16 elderly drivers aged 65 and over who have contracts with a Japanese automobile insurance company. Figure 2 shows the personal attributes of the participants. There are 5 people in their 60s, 10 people in their 70s, and 1 person in their 80s. Figure 2 (a) shows the relationship between the driving record period and age. The driving recording period varies depending on the subject, and the driving recording period is recorded for a maximum of 3 years or more. Figure 2 (b) shows the relationship between driving frequency and age. All subjects drive one day every three days. Therefore, it means that the subject is the data of an elderly driver who has been observed for a long time and is driving routinely.

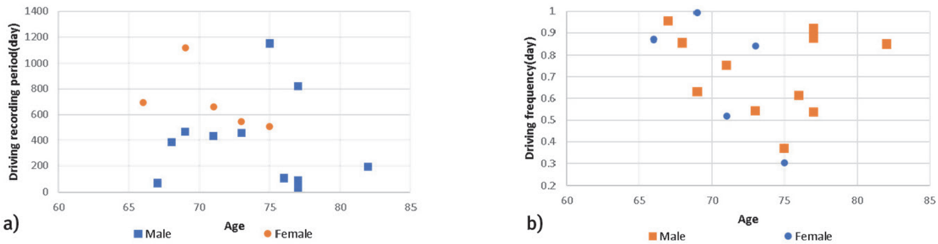

Figure 2 Attribution of participants(N=16): a) Driving recording period(day); b) Driving frequency(day)

2.2 Outline of cognitive test

The participant has mearsured a cognitive impairment their latest cognitive abilities by cognitive test. The cognitive impairment test consists of 23 items related to age, physical function, memory, spatial cognition, orientation, judgment, weakness, and illness.
In this study, elderly drivers were classified into three types based on the results of cognitive impairment tests. Table 3 shows the outline of classification types. If 5 or more items are applicable to the check items, 15 points or more in total, and 2 or more of the priority items are applicable, it is considered that there is a risk of cognitive impairment and classified as "Black".
If it does not correspond to "Black" & 5 or more applicable & 15 points or more in total & corresponds to any of the priority items, it is considered that there is a risk of cognitive impairment and classified as "Gray". Finally, elderly drivers who are neither "Black" nor "Gray" were classified as "White".
The number of subjects classified by the cognitive impairment test was 2 for "Black", 3 for "Gray", and 11 for white. It became clear that more than 30 % of the total may have dementia.

2.3 Observation device and observation method

Table 3 shows the outline of the observation method used. In this study, the accelerometer was used as the observation device. This observation device observes 3-axis acceleration (G), position information (latitude/longitude), and observation date and time at 1 second intervals(1Hz). In addition, the driving distance and vehicle speed were calculated based on the observed observation date and time and location information.

Table 1 Overview of observation device

Using device	Acceleration censor
Observation item	▪ 3-axis acceleration (G) ▪ Location information (latitude · longitude) ▪ Observation date (driving distance and vehicle speed are calculated from location information and observation date and time)
Observation interval	These data are measured at 1 Hz (1 seconds).

3 Production of analysis data

In this study, we evaluated the driving ability using the number of sudden accelerations, decelerations, and sudden steering wheel per 1km. these driving operation cause the occurrence of a traffic accident. Therefore, it was considered that the driver with a high number of these occurence ratio is related to cognitive impairment.

Sudden acceleration is counted when the vehicle acceleration exceeds 0.3g in the rear direction. Sudden deceleration is counted when the vehicle acceleration exceeds 0.3g in the forward direction. Sudden steering wheel is counted when it exceeds 0.3g in the left-right direction of the vehicle accelaration. If these driving operation is observed continuously, it has counted as one time in sequence of observations.

In this study, the index of driving ability evaluation has calculated by standardizing the number of these drving operation by the driving distace. Long-term changes focus on the degree of fluctuation of the index. Moreover, we focused on the vehicle speed when these driving operations occur. Because, the factors that these driving operation occur are different when vhecle speed is low and high. Thus, The thresholds at high speed and low speed were set to 50 km/h or more and 20 km/h or less, respectively. Other speeds are not counted.

The average value and standard deviation within the operation recording period are calculated. The average value represents the average per day from each index during the observation period. The standard deviation represents the volatility of the observation period for each index.Thus, driving ability for elderly driveris evaluated from a total of 12 items.

4 Analysis of cognitive impairment and driving ability evaluation

We constructed a model that discriminates cognitive impairment groups (“Black”, “Gray” or “White”) classified based on result of driving ability evaluation for elderly driver. The model used discriminant analysis. The objective variable set the cognitive impairment group, the explanatory variable set the result of driving ability evaluation.

The Table 2 shows the standardization discriminant coefficient of the model that discriminates the cognitive impairment groups classified into three categories based on driving ability. The Figure 3 shows discrimination scatter plot. Among the standardization discrimination coefficients, we consider variables with a large absolute value of the coefficients. First, in function 1, the standard deviation of the number of sudden deceleration occurrences during low speed driving and the average sign of the number of sudden acceleration occurrences are positive. Therefore, if this variable is large, it tends to be classified as Gray. Further, the sign is negative for the average of the number of sudden deceleration occurrences during low speed driving and the standard deviation of the number of sudden acceleration occurrences. Therefore, if these variables are large, they tend to be classified as Black. Next, in function 2, the sign of the average number of sudden steering wheel occurrences during high speed driving is positive. If this variable is large, it tends to be classified as white. The Table3 shows the discrimination results. From the Table 3, it was clarified that a model for discriminating cognitive function with high accuracy can be constructed based on the variables of driving ability described above. However, since the sample size of this analysis result is small, further study is required. In addition, long-term observed operation data cannot consider the possibility of time-series changes. Chapter 5 analyzes a long-term analysis of driving behavior.

Table 2 Standardization discrimination coefficient

Variable	Function 1	Function 2
Average number of sudden decelerations per 1 km during low speed driving	-85.264	8.817
Standard devitation number of sudden decelerations per 1 km during low speed driving	49.987	-3.689
Average number of sudden accelerations per 1 km during low speed driving	68.483	-25.115
Standard devitation number of sudden accelerations per 1 km during low speed driving	-44.271	20.966
Average number of steering handles per 1 km during low speed driving	35.571	-32.710
Standard devitation number of steering handles per 1 km during low speed driving	-38.713	22.109
Average number of sudden decelerations per 1 km during high speed driving	-8.157	19.230
Standard devitation number of sudden decelerations per 1 km during high speed driving	27.015	-32.049
Average number of sudden accelerations per 1 km during high speed driving	1.407	-23.601
Standard devitation number of sudden accelerations per 1 km during high speed driving	11.558	35.419
Average number of steering handles per 1 km during high speed driving	-20.819	42.787
Standard devitation number of steering handles per 1 km during high speed driving	18.040	-32.051

Table 3 Discrimination results

		Predicted category			Hit ratio [%]
		Black	Gray	White	
Observed category	Black	2	0	0	100.00
	Gray	0	3	0	100.00
	White	0	0	11	100.00

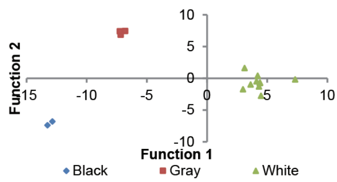

Figure 3 Discrimination scatter plot

5 Analysis of long-term changes in driving behavior

This section cleared the relationship between the characteristics of elderly drivers regarding long-term changes in cognitive ability and driving behavior. In this study, it focuses on each type ("Black", "Gray", and "White").

Figure 5 shows the time series of long-term changes in the number of sudden driving operation of each participant. Each figure shows the number of sudden accelerations per 1 km, the number of sudden decelerations per 1 km, and the number of sudden steering wheels per 1 km. However, it is difficult to grasp the overall tendency because the value of each data has small fluctuations. Therefore, a moving average is used to get a bird's-eye view by smoothing the tendency. Data values are shown in light blue dots in each figure. The solid green, red and purple lines show the moving averages for 7, 11 and 21 days.

The type of "Black" tends to increase the number of sudden steering wheels by long-term changes. Thus, it was cleared that the type of "Black" has a cognitive impairment, may have increased sudden steering wheels.

The type of "Gray" tends to decrease the number of sudden accelerations by long-term changes. Moreover, the number of sudden deceleration and sudden steering wheels rarely occur. Thus, the type of "Gray" may have cognitive impairment. However in viewpoint from of long-term change, there are few dangerous driving behavior.

The type of "White" tends to decrease the number of sudden accelerations by long-term changes. Moreover, the number of sudden deceleration and sudden steering wheels rarely occur. Thus, the type of "White" have not cognitive impairment. In viewpoint from of long-term change, there are few dangerous driving behavior.
Therefore, to grasp the long-term changes for driving behavior by elderly driver, we have shown the possibility of discriminated the "Black" type with cognitive impairment. However, it became clear that it was difficult to discriminate between "Gray" and "White". It means that it need more detailed information.

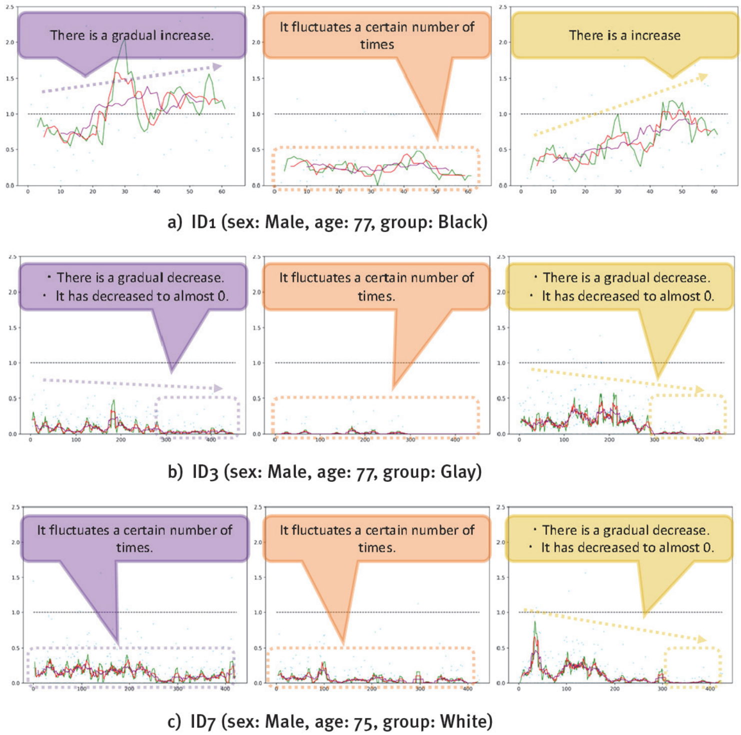

Figure 4 Time series of long-term changes in the number of sudden movements

6 Conclusions

In this study, it has become clear that verifying long-term changes in driving behavior of elderly drivers may lead to awareness of driver's license return and prevent accidents. On the other hand, there were cases where the number of sudden movements decreased regardless of the possibility of cognitive dysfunction. It is possible that subjects who do not have their own cognitive impairment are trying to drive safely. In order to verify the long-term changes of elderly drivers, it is also necessary to pay attention to conscious changes.
Especially, the tendency of the elderly drivers with cognitive impairment is remarkable. Thus, if the number of sudden braking occurrences is increase continuously, it means that it may be dangerous to continue driving.It is important to encourage elderly driver to stop driving as soon as possible.

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