イタルダ インフォメーション

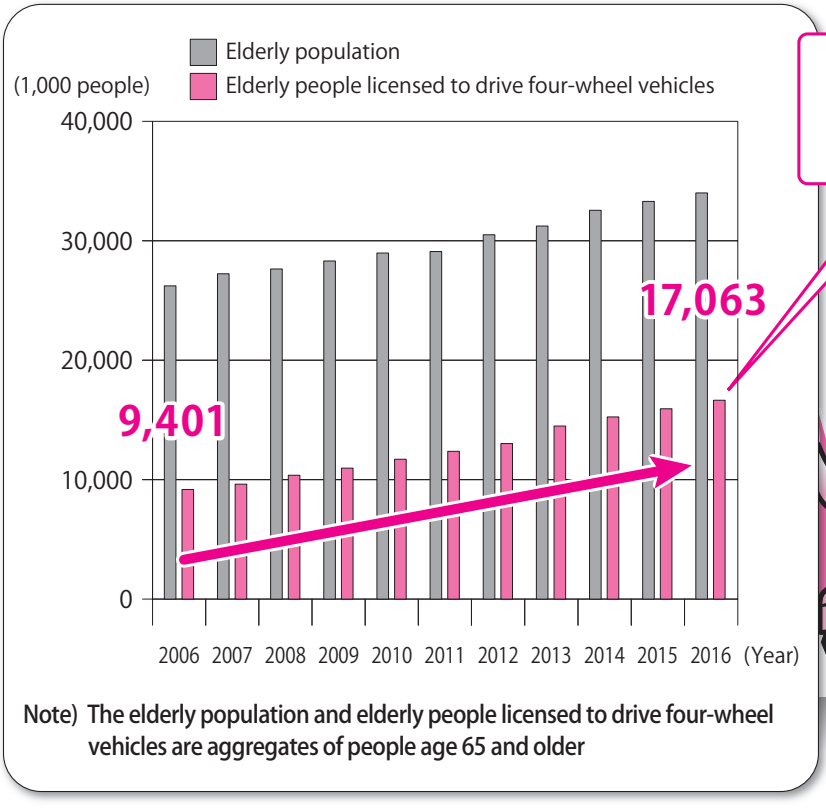
ITARDA INFORMATION

交通事故分析レポート No.124

Special feature

Accidents due to the misapplication of accelerator and brake pedals

~ For the prevention of an accident typical to elderly drivers ~



Note) The elderly population and elderly people licensed to drive four-wheel vehicles are aggregates of people age 65 and older

1 Introduction

The rate of all accidents accounted for by accidents due to the misapplication of the accelerator and brake pedals[Note 1] by age indicates that elderly drivers age 65 and over—particularly elderly drivers age 75 and over—account for a growing percentage of these. The trend is the same as it was ten years ago, with the assumption being that the effects of aging bring about a decline in driving ability. This is one type of accident that is typical to elderly drivers (Fig. 1).
The number of elderly people owning driver's licenses has nearly doubled over the past ten years, and is expected to increase still further in the future. For this reason, there are concerns over a potential increase in the number of accidents caused by a misapplication of the pedals by elderly drivers. Recently, a great deal of hope has been placed in accident prevention via safe driving support vehicles, which support drivers from the vehicle side, with the expectation being that the dissemination of such vehicles will be effective to some degree in preventing accidents. However, it will take a considerable amount of time before vehicles equipped with support features become widespread. As such, considering accident prevention measures in parallel with the dissemination of such vehicles presents an important challenge.
Therefore, this issue will focus on accidents caused by a misapplication of the accelerator and brake pedals. By analyzing locations and driving behaviors that carry a high risk of leading to such accidents, as well as case examples of accidents that actually occurred, measures such as driving methods that elderly drivers should pay heed to in order to prevent accidents due to the misapplication of the accelerator and brake pedals will be proposed.

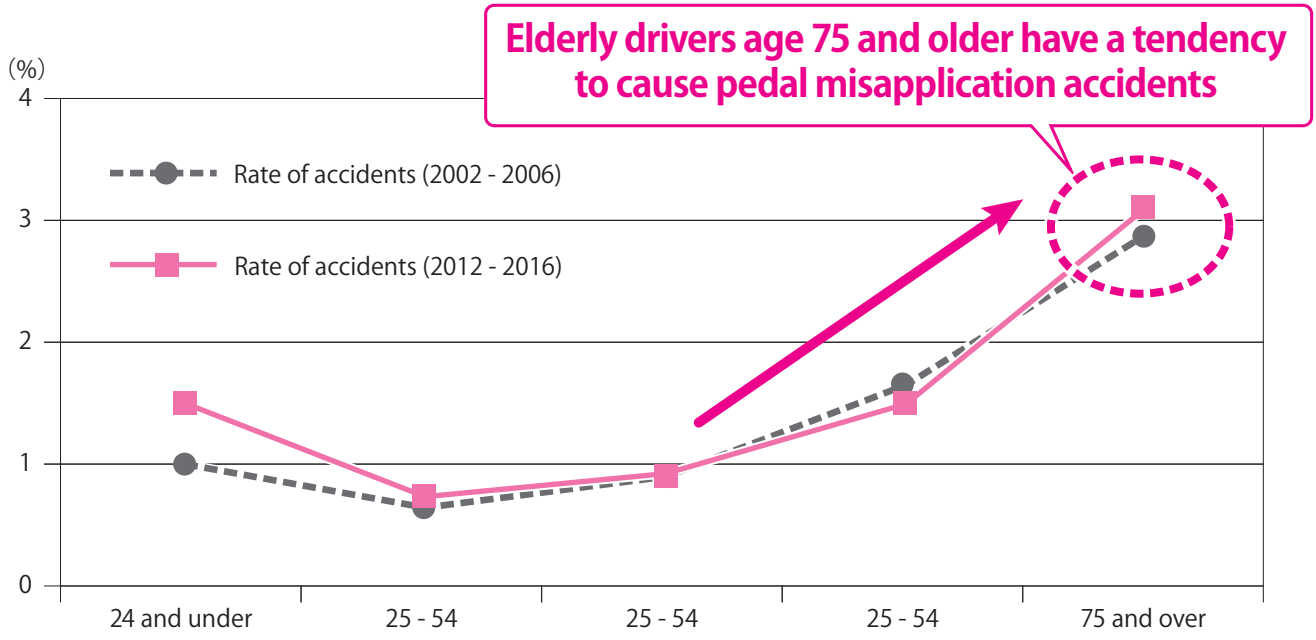


Fig. 1. Rate of pedal misapplication accidents for the primary party driving a four-wheel vehicle by age group (excluding special cars and mini-cars)

Note 1. Rate of accidents = Number of pedal misapplication accidents ÷ Total number of accidents

2 Actual status of pedal misapplication accidents

■ Characteristics of the locations where accidents occur (number of accidents)

At what sorts of locations do pedal misapplication accidents frequently occur?
Fig. 2 compares the number of pedal misapplication accidents that occurred whereby the primary party[Note 2] was driving a four-wheel vehicle other than a special car or mini-car (hereafter referred to as "four-wheel vehicles") for the three age groups of 64 and under (hereafter referred to as "non-elderly"), 65 - 74, and 75 and over. This graph compares the trends from ten years ago (past: total values from 2002 - 2006) with the present (total values from 2012 - 2016) by road type. It indicates that the largest number of accidents occurred along non-intersection roads among all of the age groups. One characteristic observed with the elderly group is the fact that they cause a great many accidents in general traffic locations (parking lots and similar locations),[Note 3] which are seeing the greatest rate of increase out of the different road types.

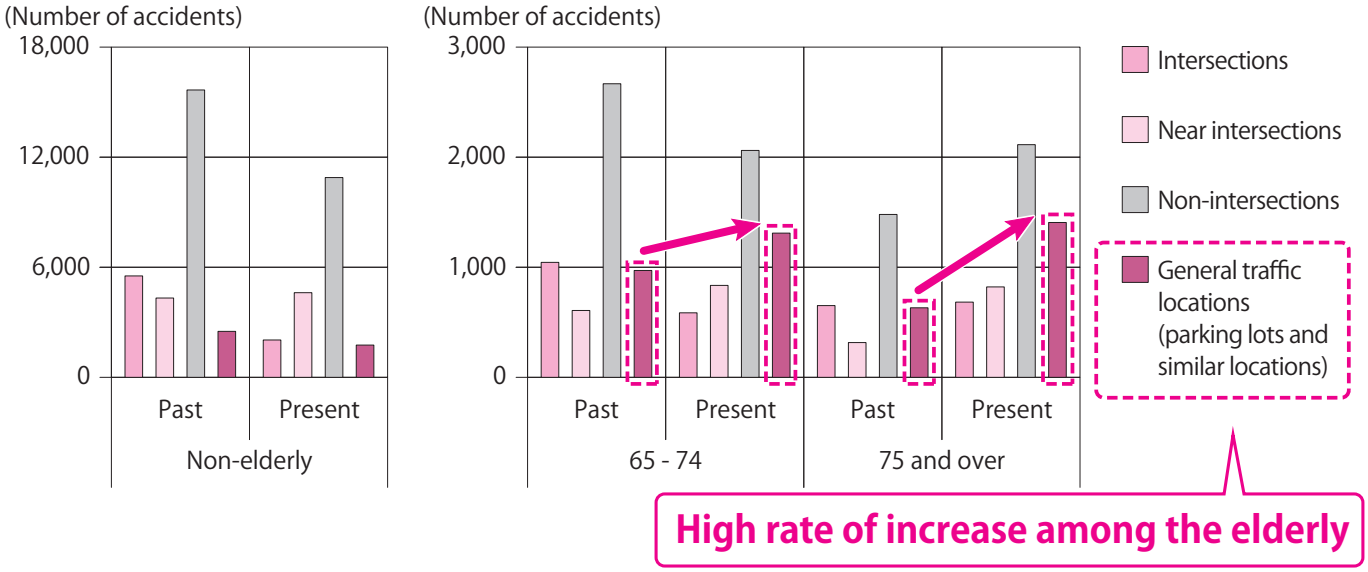


Fig. 2. Number of pedal misapplication accidents for the primary party driving a four-wheel vehicle by age group and road type (Past: 2002 - 2006; Present: 2012 - 2016)

Note 2. The primary party refers to the party with the greatest degree of fault out of the parties involved in a traffic accident. In cases where the parties are at equal fault, it refers to the person who suffered the least amount of personal harm.
Note 3. General traffic locations (parking lots and similar locations) include the service areas along expressways and the like, store parking lots, coin parking areas, and so forth.

■ Characteristics of the locations where accidents occur (rate of accidents)

Next, we will take a look at road types where pedal misapplication accidents tend to occur by the rate of accidents based on the number of accidents listed above.

Fig. 3 shows the rate of pedal misapplication accidents out of all accidents where the primary party was driving a four-wheel vehicle by age and road type. The rate of accidents by road type reveals that the rate of accidents by the elderly group in general traffic locations (parking lots and similar locations) is high compared with those on other road types, with no changes in this seen with the numbers from ten years ago. This trend seems to be particularly pronounced among elderly people age 75 and over, though the trend is similar for non-elderly people for whom the rate of accidents is low. This suggests that general traffic locations (parking lots and similar locations) are at high risk for the occurrence of pedal misapplication accidents, which holds true for all age groups. In other words, locations used for general traffic besides public roads, such as parking lots, constitute road environments where factors that influence driving appear most often. Conversely, the rate of such accidents at intersections, near intersections, and on non-intersection roads (which had the largest number of accidents) is lower compared with that of general traffic locations (parking lots and similar locations).

Therefore, for the analysis from here on the focus will be narrowed to general traffic locations (hereafter referred to as “parking lots and similar locations”), which tend to pose a high risk of accidents for elderly drivers, as we take a look at the characteristics of accidents that are unique to such locations.

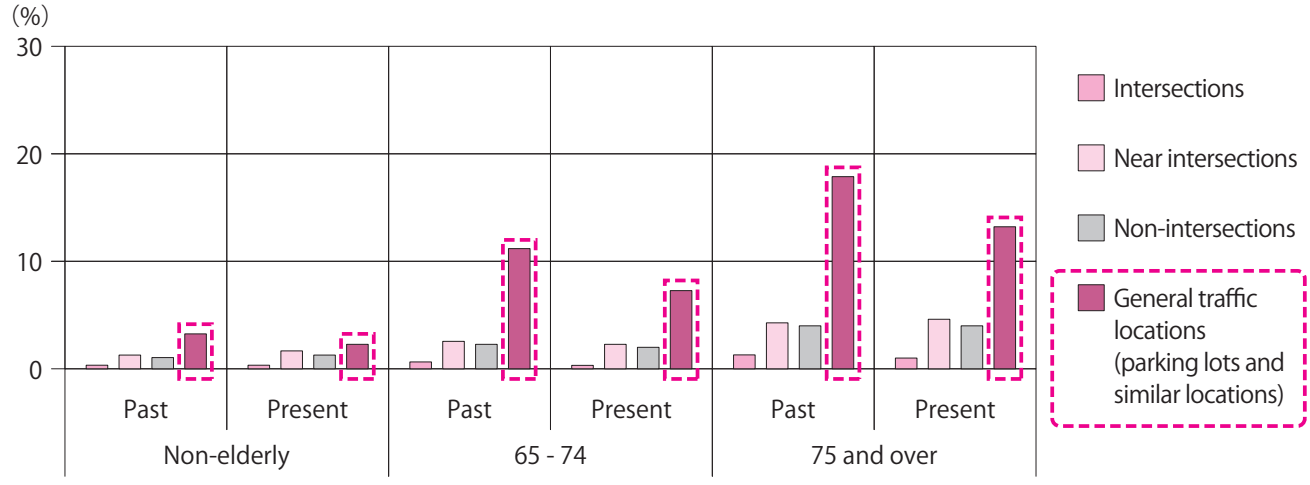


Fig. 3. Rate of pedal misapplication accidents for the primary party driving a four-wheel vehicle by age group and road type (Past: 2002 - 2006; Present: 2012 - 2016)

3 Characteristics of accidents that occur in parking lots and similar locations

■ Typical accident patterns

Table 1 indicates the connection between driving behavior and typical patterns presumed to involve a greater tendency for pedal misapplication accidents to occur based on articles reported in newspapers and the like covering pedal misapplication accidents that have actually occurred in parking lots and similar locations, as well as in-depth case studies possessed by ITARDA (hereafter referred to as “microdata”). The effects of aging shown in the right-hand side of Table 1 show selected items that are thought to affect driving as a result of general age-induced decline.

Regarding the typical patterns whereby it is believed that such accidents possibly occur, there are multiple points of overlap for elderly drivers between the “Effects of aging” and the “Presumed causes of pedal misapplication,” that tend to lead to pedal misapplications. As a result, these have an effect on driving and increase the possibility of driving errors occurring, and therefore presumably magnify the possibility that pedal misapplications will occur.

Table 1. Typical patterns for pedal misapplication accidents that occur in parking lots and similar locations

Driving behavior	Typical patterns	Presumed causes of pedal misapplications	Effects of aging
Starting up	• Moving the vehicle for forward parking • Adjusting position while parking • Starting up from a parking spot	• Increased frequency of switching between pedals (increased number of sharp turns) • Suddenly starting up	• Decline in visual function • Decline in attentiveness and concentration • Delayed and erroneous information processing • Greater-than-expected loss of physical movement (delayed / imprecise movements) • Decline in physical flexibility (joints stiffen and range of motion becomes more constricted)
Moving straight	• When heading towards a parking spot • When heading towards the parking lot’s entrance	• Increase in number of times speed is adjusted (increased use of brakes) • Failing to pay attention when driving (distracted driving, etc.) (Sudden use of pedal)	
Reversing	• Reversing in order to park the car • Starting up in reverse out of a parking space	• Turning one’s body around to look backwards • Increased frequency of switching between pedals (increased number of sharp turns) • Suddenly going into reverse	
	Patterns by which accidents occur		Effect on driving

■ Characteristics by type of movement

What sorts of driving behavior was the driver engaged in when the accident occurred in parking lots and similar locations? Fig. 4 shows the rate of pedal misapplication accidents where the primary party was driving a four-wheel vehicle that occurred in parking lots and similar locations by age group and type of movement based on accident data from 2012 - 2016. From the totals in Fig. 4 it can be seen that a higher rate of accidents occurred when starting up[Note 4] and moving straight,[Note 5] with this true for all of the age groups. There is a particular increase in this rate the older the driver is, indicating that the risk of someone causing an accident increases as they grow older. Yet at the same time, the rate of accidents when turning left / right or when reversing is lower compared with that from starting up and moving straight for all age groups.

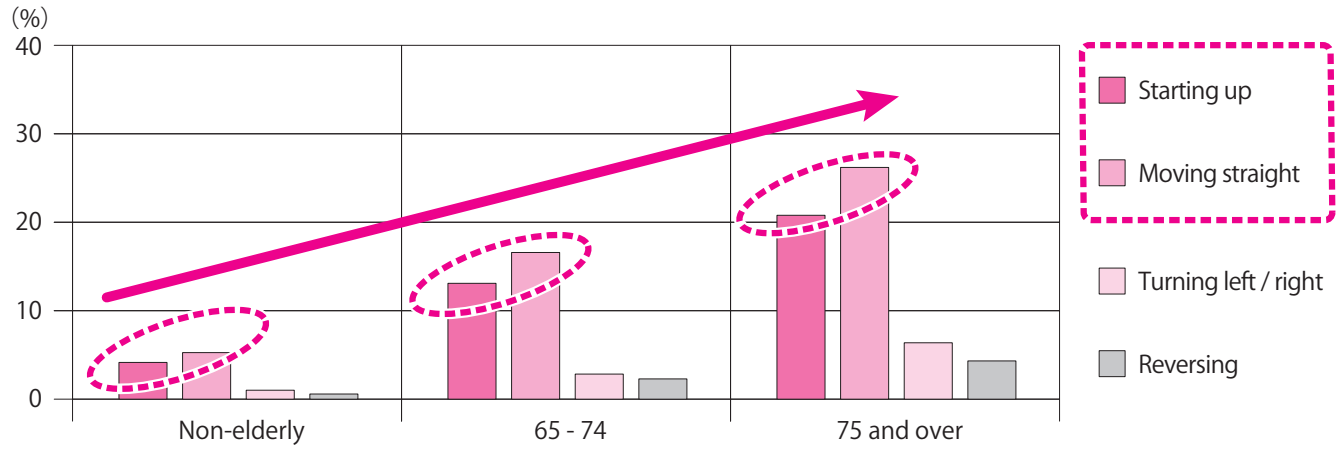


Fig. 4. Rate of pedal misapplication accidents by age of the primary party when driving a four-wheel vehicle and by type of movement in parking lots and similar locations (2012 - 2016)

Note 4. Starting up refers to when a vehicle that had been stopped begins moving forward (the interval until the driver has traveled out of the blind spot range; with medium-sized passenger cars, this covers up until they have traveled about five or six meters).
Note 5. Moving straight refers to when a driver is driving almost completely straight ahead along a roadway without changing lanes or turning (total value from accelerating, maintaining a constant speed, and decelerating).
Note 6. Other types of movement were excluded from the comparison because they feature a small number of accidents with no detectable significant difference.

■ Characteristics by type of accident when starting up / moving straight

When “starting up / moving straight,” which are driving behaviors that tend to carry a high risk of accidents occurring in parking lots and similar locations, what sorts of accidents actually occur?
Fig. 5 shows the composition rate for pedal misapplication accidents where the primary party was driving a four-wheel vehicle by type of accident and age group, focusing on accidents when starting up / moving straight in parking lots and similar locations. One characteristic this reveals with the elderly group is that they have a higher rate of single vehicle accidents, particularly collisions with roadside structures such as a house, wall, or similar structure. Conversely, non-elderly drivers have a higher rate of vehicle-vehicle accidents, while no differences are seen with the rate of pedestrian-vehicle accidents across any of the age groups.

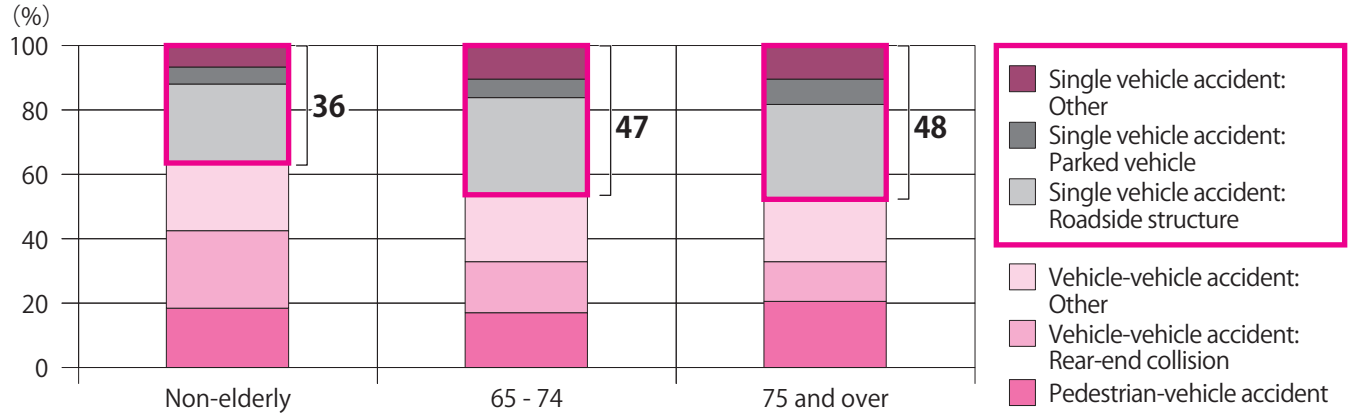


Fig. 5. Composition rate of pedal misapplication accidents by type of accident when starting up / moving straight in parking lots and similar locations by age group of the primary party driving a four-wheel vehicle (2012 - 2016)

■ Pattern diagrams of typical accidents when starting up

Using presumed accident patterns when starting up / moving straight found by referring to the typical accident patterns shown in Table 1, let us look at the hypothetical cases involving collisions with roadside structures that are represented in diagrams. Figs. 6 and 7 attempt to show accidents that occur from among those pedal misapplication accidents presumed to occur when starting up, including:

- ● When starting up temporarily to adjust the vehicle’s position when parking (see Fig. 6. When starting up (1))
- ○ When starting up from a parking space
- ○ When moving the vehicle for forward parking
- ● When moving the vehicle for forward parking after the vehicle’s position has been adjusted (See Fig. 7. When starting up (2))

In such cases, drivers must maneuver in the limited space of parking lots and similar locations. As a result, factors like the increased incidence of switching between the accelerator and brake pedals as a result of sharply turning the vehicle, as well as the tendency to suddenly start up, presumably lead to more accidents.

● When starting up (1)

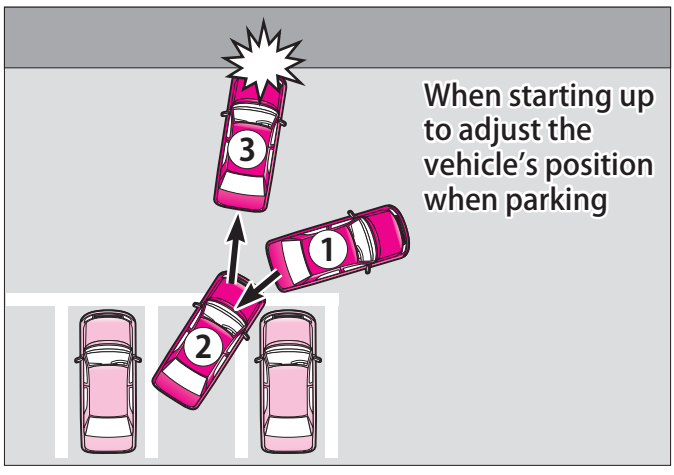


Fig. 6. Typical accident pattern when starting up

● When starting up (2)

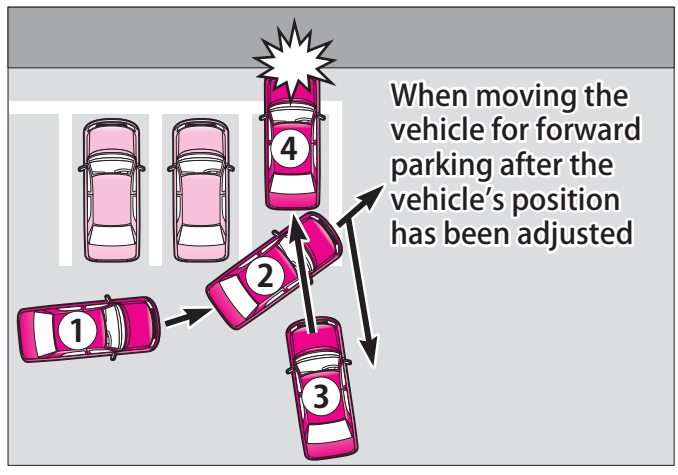


Fig. 7. Typical accident pattern when starting up

■ Pattern diagrams of typical accidents when moving straight

Fig. 8 attempts to show accidents that occur from among those accidents presumed to have involved a pedal misapplication by changing the aforementioned conditions with those that obtain when moving straight, including:

- While heading towards a parking spot and while heading towards the parking lot's entrance (see Fig. 8. When moving straight)

When moving through parking lots, due to factors like the presence of pedestrians and other vehicles, as well as searching for parking spaces, drivers operate the brake pedal more to modulate their speed, and tend to suddenly step on the pedals as a result of their tendency towards distracted driving in which they are too attentive to pedestrians and the like. These and similar such conduct presumably lead to accidents.
When driving by starting up or moving straight within parking lots and similar locations, it is important that drivers endeavor to drive while paying careful attention to potentially hazardous points where accidents occur.

● When moving straight

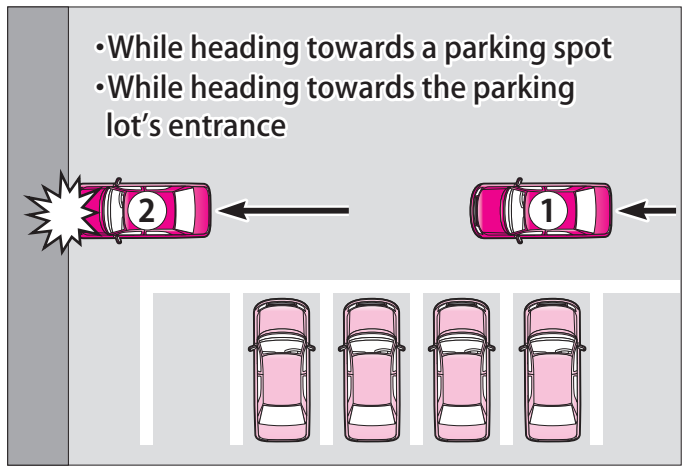


Fig. 8. Typical accident pattern when moving straight

4 Human factors behind pedal misapplication accidents

Fig. 9 shows the sorts of conditions under which operating errors are more prone to occur by the human factors that affect driving through the use of data on drivers who engaged in improper driving (focusing on all ages) from the microdata in ITARDA's possession. This graph indicates accidents by using pedal misapplication accidents, as well as accidents caused by operating errors such as steering error and braking error, for which there are a large number of accidents, as subjects for comparison.
Of the human factors for drivers, "Getting flustered / panicking" is the most common factor for all the operating errors, and was common to all accidents caused by the three types of operating errors. This suggests that it has a pronounced effect on driving. When drivers perceive some sort of danger and take evasive action, they could conceivably get flustered or panic, which would lead to operating errors and result in accidents. It is crucial that driver attentiveness to things like confirming safety be enhanced to ensure that drivers do not encounter situations in which they may get flustered or panic, or get involved in situations where there is the risk of an accident occurring.
With pedal misapplications, the "old age-related factors" indicated in the aforementioned analysis outstripped accidents from the other operating errors, and were observed to be a characteristic of typical accidents by elderly drivers. Another characteristic is the prevalence of human factors that have an effect on driving in and of itself, such as being unfamiliar with a car.

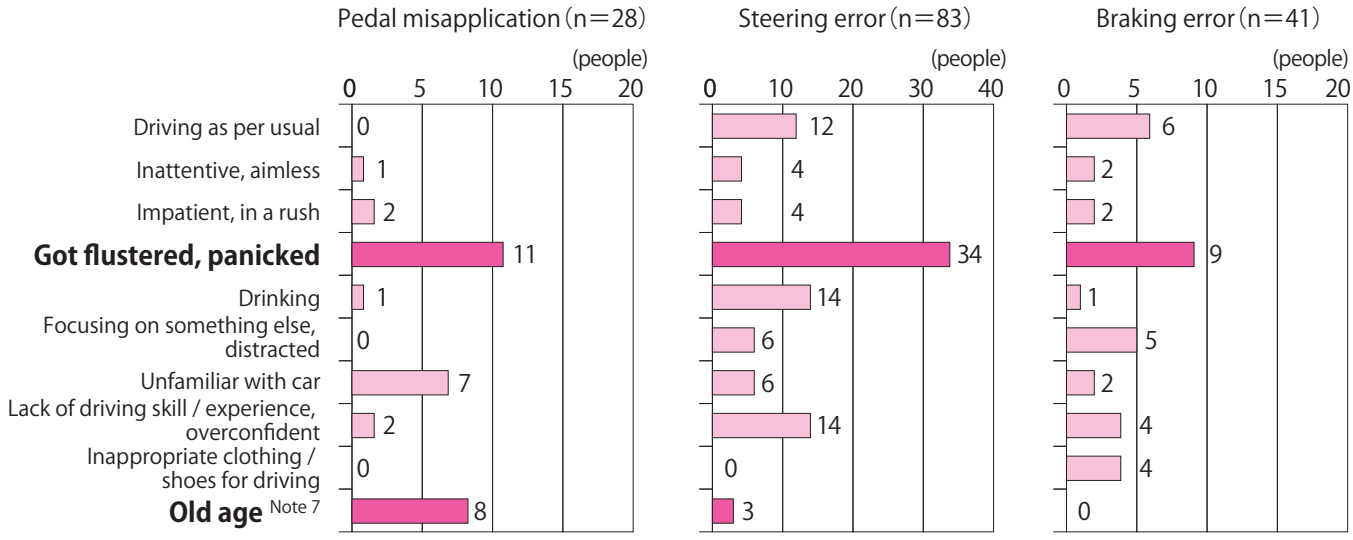


Fig. 9. Human factors of drivers that caused operating error accidents (multiple responses accepted)

(Focusing on all ages)
Fig. 10 from Reference Literature 3 is altered)

Note 7. Old age here is used to mean cases where it has been determined that a person's driving is impaired as a result of aging.

5 Survey examples on the sitting postures and pedal operation of elderly drivers[5)]

■ Driving behavior whereby drivers use their right foot to work the pedals by altering their driving posture

As opposed to the aforementioned cases of starting up and moving straight, when reversing it is conceivable that some drivers alter their driving posture, which tends to lead to more pedal misapplication accidents as a result of the reduced physical flexibility of elderly drivers. Pedal misapplication accidents when reversing are not as common as those while starting up or moving straight, but they are believed to be a typical accident that occurs due to the decline in physical functionality seen with elderly people. Therefore, in this section some of the test results on driver's sitting posture and the driving behavior of alternating between pedals while reversing carried out jointly by the Faculty of Engineering of Fukuyama University and ITARDA will be introduced.

This study referred to a previous study stating that the angle of motion of the hip joints of elderly people (hereafter referred to as the "internal rotation angle" Note 8) grows smaller as people age, and tried to verify whether there was a tendency for elderly drivers to place their right foot in a position close to the accelerator pedal as a result of altering their driving posture. For example, it's conceivable that when elderly drivers apply the brake pedal with their upper body twisted to the right while driving, they may naturally shift the foot they use to work the pedals to the right without realizing it and end up pressing the accelerator pedal when they meant to press the brake pedal. As indicated in Fig. 10, the study tested the driving behavior of alternating between pedals in a hypothetical scenario of reverse parking involving drivers looking backwards with their head protruding from the right-hand side door of their vehicle from among the driving behaviors whereby people alter their driving posture. When this experiment was run on young people, the results revealed that they had a tendency to shift the position of their right foot, which they use to work the pedals, towards the accelerator pedal side due to altering their driving position. Based on this, presumably there will be an even more pronounced likelihood that elderly drivers will shift the position of their right foot that they use to work the pedals towards the accelerator pedal side.

Therefore, the attempt was made to clarify what effect the open angle of both of the driver's thighs and the angle of inclination of the right foot in both directions versus the brake pedal has on pedal misapplications by elderly drivers. This was done by experimentally testing the connection between the sitting postures of elderly drivers and the driving behavior of using their right foot to operate the pedals.

Note 8. The internal rotation angle is the angle of motion produced when attempting to point the toes and knees of one's leg inward.

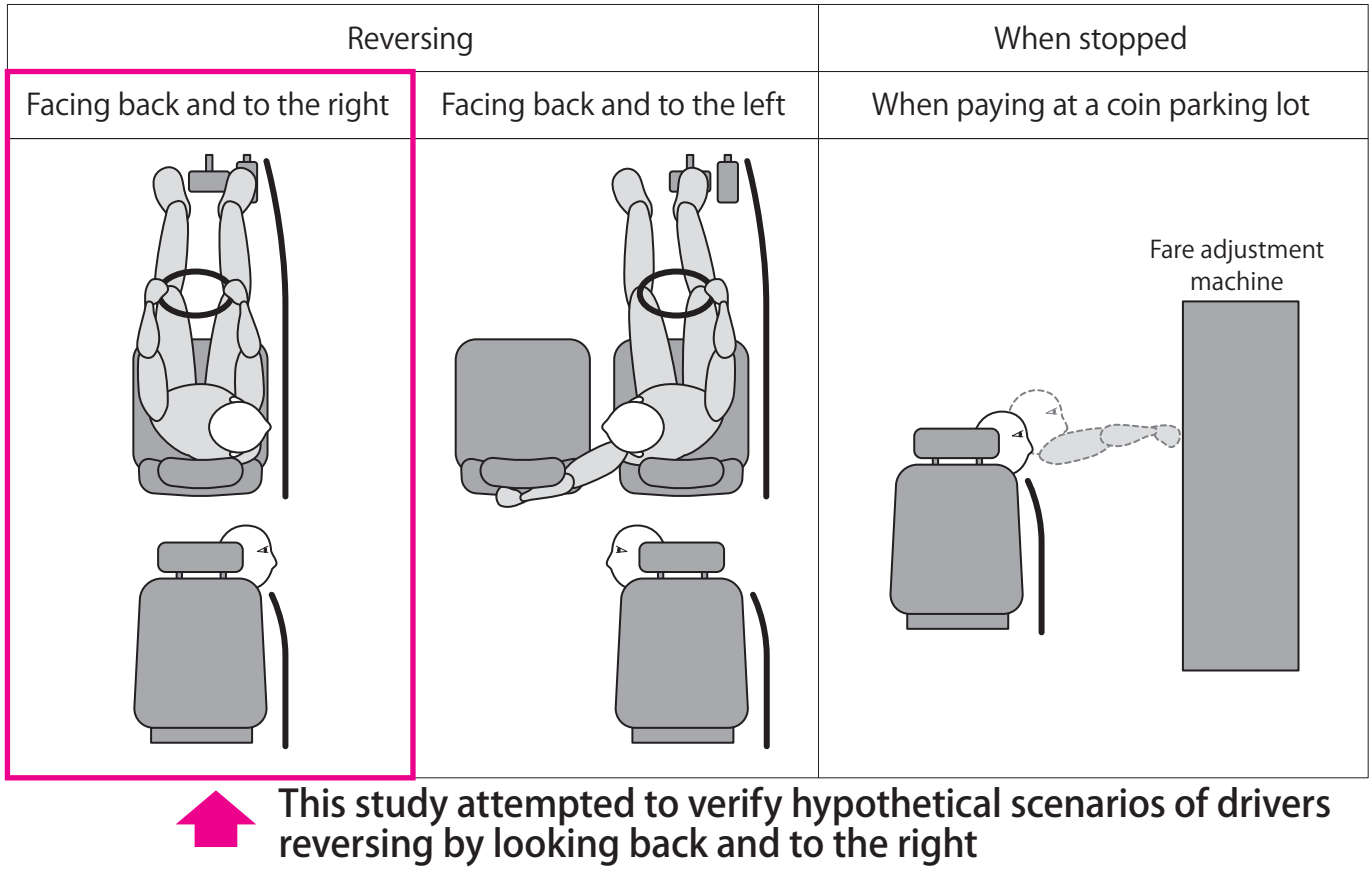


Fig. 10. Driving behavior of altering one's driving posture

■ Study methodology

Fig. 11 shows the test method for a hypothetical scenario conducted on elderly drivers involving them driving in reverse to park their vehicle in parking lots and similar locations. After adjusting the seat position to suit each of the individual elderly drivers, they were asked to repeatedly alternate between the brake and accelerator pedals with their right foot while maintaining a certain posture in which they twisted their upper body to the right and looked backwards. The points of focus for elderly drivers from among the driving behaviors involving alternating between pedals were the connections between:

- The open angle of both thighs shown in Fig. 12 (θ1)
- The angle of inclination of the right foot versus the brake pedal shown in Fig. 13 (θ2)
- The distance from the left edge of the brake pedal to the position where the right foot steps on the pedal shown in Fig. 14

For the vehicles used in the verification, a compact car and a small-sized passenger car with automatic transmissions and engine displacement of no more than 1,500cc were chosen for the test vehicles. This was based on the large number of responses to a questionnaire performed on elderly drivers in advance asking what model vehicles they normally drive. Markings were applied to both pedals to make it easier to measure the locations where the drivers stepped on the pedals on the test vehicles. Video cameras were installed underfoot and set to record in order to identify the positions where the elderly drivers stepped on the pedals when alternating between them.
The elderly drivers subject to analysis in this test consisted of 40 men and 6 women between the ages of 62 - 86 for a total of 46 people. Of these, 19 people (17 men and 2 women; average age of 74.9) drove the compact car and 27 (23 men and 4 women; average age of 73.5) drove the small-sized passenger car.

Fig. 11. Posture of facing backwards by turning one's upper body to the right

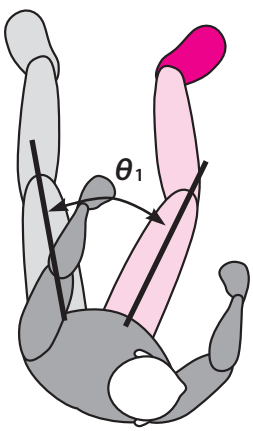


Fig. 12. Open angle of both thighs

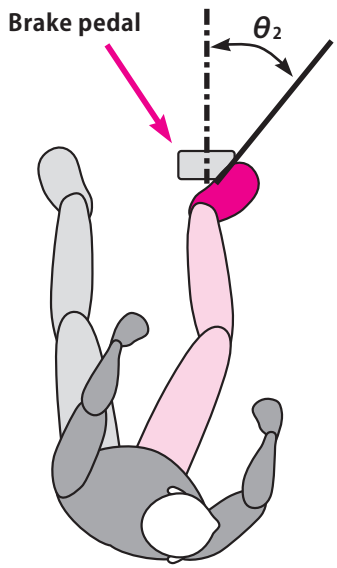


Fig. 13. Angle of inclination of the right foot

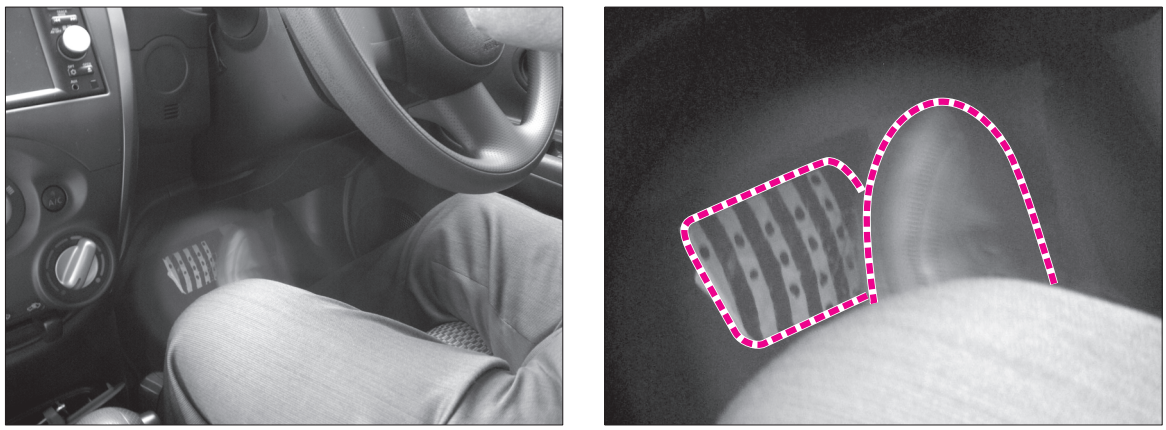
Distance from the left edge of the pedal

Fig. 14. Position where the driver steps on the brake pedal

■ Study results

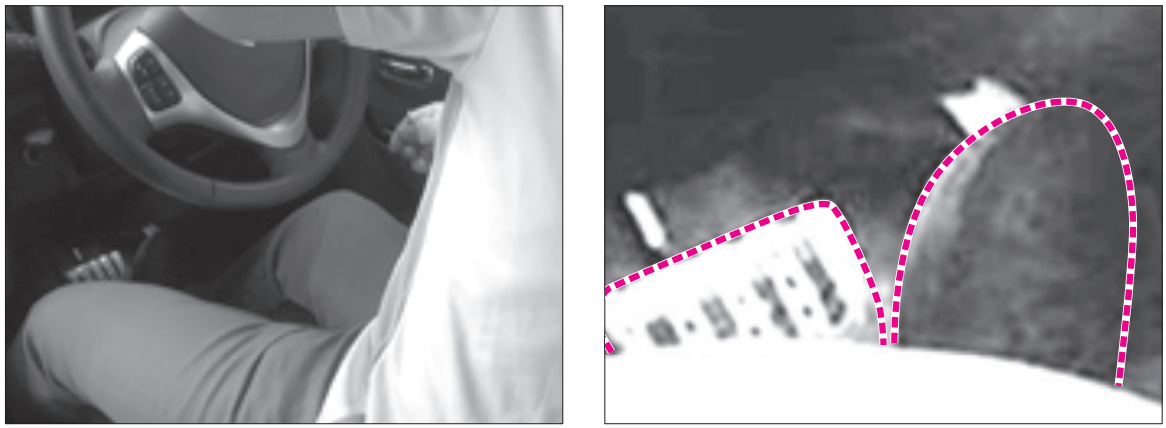
Fig. 15 shows the test cases involving the male elderly drivers carried out using the compact car, while Fig. 16 shows the test cases of said drivers carried out using the small-sized passenger car. Common results with the male elderly drivers on both of the test vehicles involved cases in which they widely opened both thighs, as well as cases where they inclined their right feet significantly to the right to apply the brake pedal. Cases seen with the male elderly drivers where they have a large open angle between both thighs and a large angle of inclination with the right foot often resulted in cases where they would use their right foot to apply the brakes at a position on the right edge of the brake pedal, close to the accelerator pedal. Among the female elderly drivers there were cases in which they checked behind them in a position with both thighs closed, and operating the pedals in a manner that carried a lower chance of causing pedal misapplication accidents. But similar to the male elderly drivers, majority of the cases had both their thighs wide open and had inclined their right foot significantly to the right to apply the brake pedal at a position close to the accelerator pedal. Both the male and female elderly drivers tended to have a smaller internal rotation angle compared with young people. Based on this, it is presumed that the foot elderly drivers use to apply the pedals shifts to a position that is closer to the accelerator pedal the older they get.

Through this experiment, the connection between the open angle of both thighs of elderly drivers and the position where they step on the pedals by type of vehicle for the two test vehicles was observed. Doing so revealed a tendency for the open angle of both thighs to be wider and the range of variance in the position where they stepped on the pedals to be broader with the compact car more so than the small-sized passenger car. This is thought to be influenced by the different pedal layouts between the compact car and the small-sized passenger car versus the position of the driver seat.



Open angle of both thighs　　Right foot stepping on the brake pedal

Fig. 15. Posture of both thighs and the right foot (compact car)



Open angle of both thighs　　Right foot stepping on the brake pedal

Fig. 16. Posture of both thighs and the right foot (small-sized passenger car)

■ Considerations regarding the driving posture of elderly drivers and driving behavior that leads to pedal misapplications

Fig. 17 shows the connection that the decline in the physical flexibility of elderly drivers has on their sitting posture and pedal misapplications based on the knowledge gained through this test. The following tendencies were observed in elderly drivers when alternating between pedals when they were in a posture of driving in reverse with their upper body twisted to the right and looking backwards.

- Operating the pedals in a manner whereby they hardly move their hip joints as a result of adopting a posture with their legs spread wide.
- Operating the pedals while sitting in their seat in a posture with their right thigh twisted slightly to the right.
- Operating the pedals in a posture where their right foot is inclined towards the right.

As a consequence of this, when elderly drivers apply the brake pedal in a posture where their upper body is tilted to the right and they are looking backwards, they tend to step on the pedal in a location that is close to the accelerator pedal. This presumably results in people accidentally applying the accelerator pedal when they meant to apply the brake pedal.

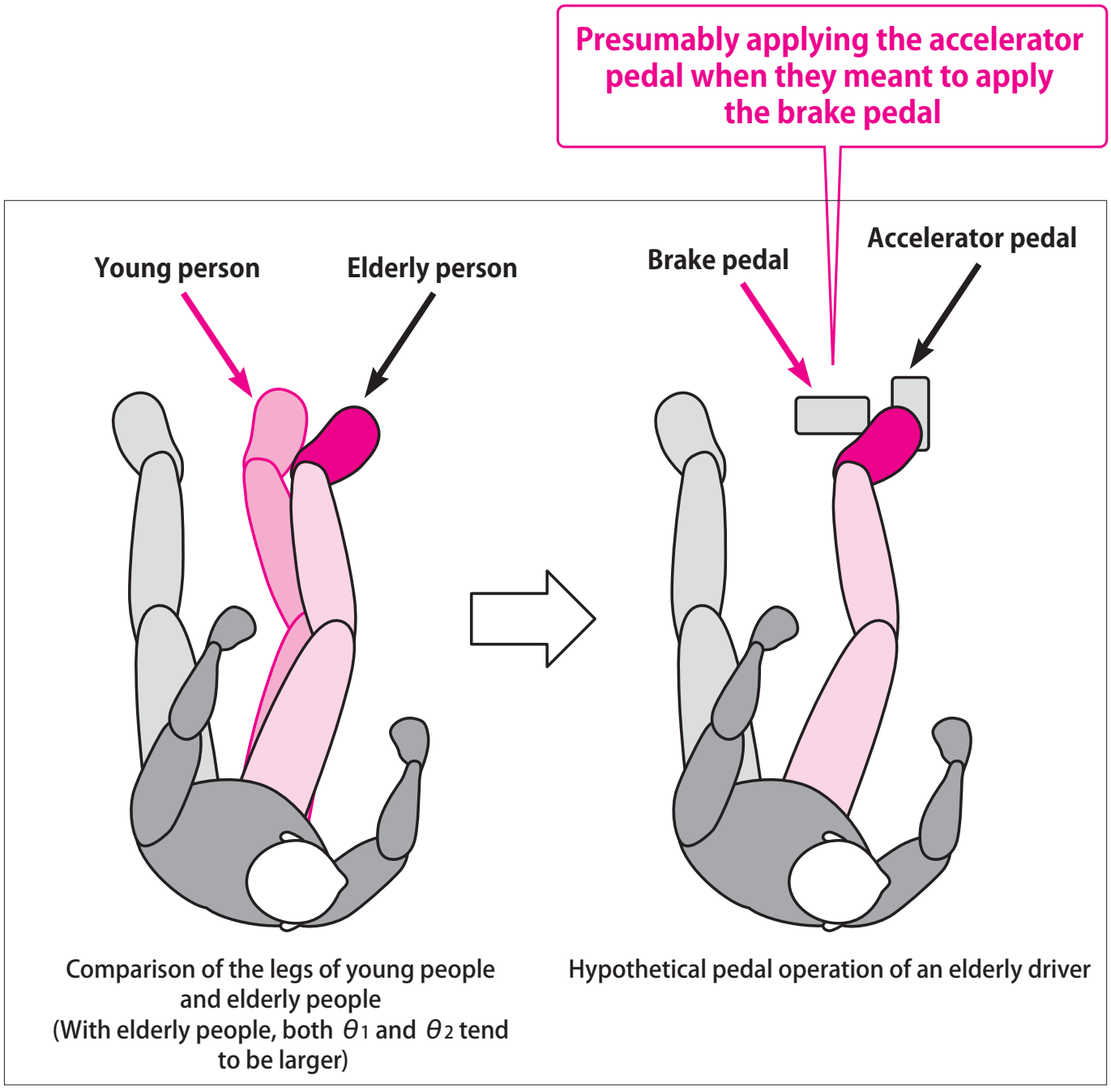


Fig. 17. Hypothetical posture when driving in reverse by twisting one's upper body to the right and looking backwards

6 Conclusion

As we have seen thus far, accidents due to the misapplication of the accelerator and brake pedals caused by elderly drivers have the following characteristics.

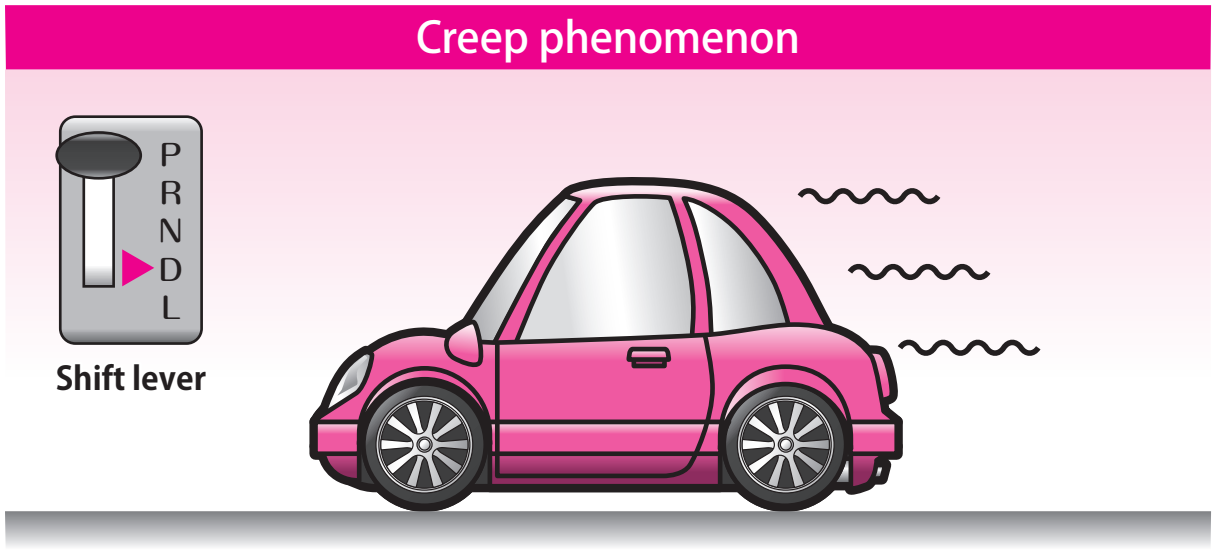
- There is a high incidence rate of such accidents in parking lots and similar locations, such as store parking lots and coin parking areas.
- Driving behavior in parking lots and similar locations involve a higher rate of accidents when starting up and moving straight, with the rate of these increasing the older the person is.
- Regarding the types of accidents when starting up / moving straight in parking lots and similar locations, there is a high rate of accidents from collisions with roadside structures.
- Regarding the human factors for pedal misapplications, in addition to old age-related factors many are caused by the driver getting flustered or panicking.
- Examples from an assessment concerning the sitting posture and pedal operation of elderly drivers revealed that they have a tendency to place the right foot they use to step on the brake pedal near to the accelerator pedal's side when reversing in a posture where their upper body is turned to the right and they are looking backwards.

Based on the results of this analysis, it would be effective to make the following efforts when driving in order to prevent pedal misapplication accidents by elderly drivers.

To prevent pedal misapplication accidents:

■ Use the creep phenomenon [Note 9]

Driving in parking lots and similar locations generally involves traveling through low-speed zones with limited space. With automatic transmission vehicles, drivers should work to drive by utilizing the vehicle's creep phenomenon according to the circumstances to the extent possible, whereby they rest a foot on the brake pedal when starting up or moving straight.



Usage example 1) Conceivably effective in parking lots and similar locations where drivers frequently alternate between the brake and accelerator pedals

Usage example 2) Conceivably effective at preventing sudden start-ups

Note 9. The creep phenomenon refers to a phenomenon with automatic transmission vehicles whereby shifting the shift lever into drive (positions other than P (Park) and N (Neutral)) will cause the vehicle to move slowly even without pressing the accelerator pedal.

Continue to Page 12 for other ways "To prevent pedal misapplication accidents."

■ Be cautious of pedestrians and vehicles emerging from unexpected places

In parking lots and similar locations there are numerous blind angles and pedestrians and vehicles emerge from unexpected places, and such sudden and abrupt occurrences could potentially fluster drivers and increase the likelihood that they will misapply the pedals. To ensure that drivers do not get flustered or panic, they should make efforts to determine the situation around them, enhance their attentiveness, and ensure that they can respond calmly even in unforeseen circumstances.

■ Check on one's driving once again

Owing to the decline in their physical abilities and flexibility, elderly drivers are not as physically mobile as they imagine, and therefore presumably engage in operating errors unintentionally. It is important that each driver adopt a seat position that is suited to them, as well as a proper driving posture that is reasonable and proper for driving. Drivers should maintain an awareness of safety in order to drive soundly and correctly, such as by checking to ensure they do not have any erroneous driving tendencies, and checking on their foot position when operating the pedals.

■ Concentrate on driving

Drivers should strive to adopt a driving style that allows them to maintain a sense of self-composure on a routine basis and create environments where they can concentrate on driving, such as refraining from operating car navigation systems and the like at the same time they are driving, in an effort to prevent pedal misapplications.

(Akihiro Hirakawa)

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