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Osaka University
THE BACKGROUND FACTOR OF THE DRIVING COMPENSATION BEHAVIOR AMONG ELDERLY DRIVERS

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Abstract

The purpose of this study is to examine what factors lead to driving compensation behavior among elderly drivers, particularly focusing on the effect of self-reported driving performance, and to investigate the relationship between driving compensation behavior and traffic accidents or violations. After analyzing 237 elderly drivers, the results showed that whereas self-reported driving performances influenced driving compensation behaviors, the relationship between self-reported driving performances and driving compensation behaviors contradicted because of the differences in driving behaviors. Furthermore, the results indicated that the driving compensation behaviors were effective in preventing traffic accidents and violations.

Key words: elderly driver, driving compensation behavior, self-reported, traffic accident, traffic violation

1. Introduction

In 2012, the population percentage of individuals aged 65 or older (population aging rate) in Japan was 24.1%, currently the highest rate in the world (Cabinet Office, Government of Japan, 2013). In 2013, the population percentage of senior citizens with driver’s licenses was 18.7%, and senior citizens comprised 26.6% of total deaths occurring while driving: a record percentage, and one that is showing signs of increasing (National Police Agency, 2014). As individuals age, their driving habits—driving speed, checks, etc.—undergo change, revealing driving characteristics that are unique to elderly individuals (Okamura & Fujita, 1997; Renge, Ishibashi, Oiri, Oota, Tsunenari, & Mukai, 2003; Renge, Tada, Usui, & Renge, 2010). It is possible that
such unsafe driving behavior of these elderly individuals is triggering accidents.

However, while deterioration in driving skills, brought about by age-induced deterioration of physical functions, is a likely cause of accidents, it has been suggested that elderly drivers, themselves aware of such changes, make conscious efforts to adapt their actions, for example by reducing exposure to driving (Cushman, 1996; Akamatsu, Hayama, Iwasaki, Takahashi, & Daigo, 2005; Holland & Rabbitt, 1992). In Sato, Akamatsu, Iwasaki, Imaizumi, and Daigo’s paper (2007), they created a countermeasure action questionnaire, and identified seven factors in the results, such as ‘avoiding driving in adverse conditions’ and ‘avoiding multitasking’. It is possible, then, that deterioration in driving skills does not always result in increased accidents. Furthermore, it has been found that elderly drivers compensate their driving to maintain a longer distance from the car in front (Nishida, 1998), than non-elderly drivers tend to do. It may therefore be the case that elderly individuals respond to the decline in their physical and mental functions caused by age, by adapting their actions accordingly, so that they can continue to drive while avoiding accidents. Regarding this, Baltes & Graf (1996) have proposed the concept of Selective Optimization with Compensation (henceforth referred to as SOC). The SOC theory is defined as a seasoned general strategy that the elderly adopt, making effective adjustments in their lives when faced with the impairment of physical and mental functions caused by age. This is considered to be a countermeasure that is enacted when the elderly fail to keep to their familiar standards, due to impaired physical and mental capabilities. This present study, following the SOC theory, deems ‘driving compensation behavior’ as the comprehensive actions of elderly drivers who recognize their own declining driving capabilities, and compensate for the age-induced deterioration of their physical and mental capacities and their driving skills, by driving safely. The hypothesis is that drivers adapt the way they drive, by recognizing that their driving skills decline with age; it follows that lower self-reported driving performance may promote driving compensation behavior. However, the mechanism that prompts people to engage in driving compensation behavior is still unknown. This is why it is necessary to examine the influence of self-reported driving performance, as a background factor of driving compensation behavior.

Furthermore, in previous research on physical and mental functions, particularly concerning sight, there have been reports that elderly drivers recognize the change in their eyesight and adapt their driving habits accordingly, avoiding driving at night, on unfamiliar roads, or over long periods of time (Zur & Shinar, 1998). According to Marottoli, Richardson, Stowe, Miller, Brass, Cooney, & Tinetti (1998), deterioration of vision, difficulty rotating the neck, and decrease in visual attention performance, correlate with the avoidance of driving in elderly drivers. The studies conducted by Sato et al. (2007) on the relationship between the degrees of age-induced physical/mental changes and countermeasure actions, showed that each countermeasure action was in fact influenced by conscious change in capacities. On the other hand, although age, gender, health status, and cognitive functions directly influence both exposure to driving and
driving avoidance, physical functions have been shown not to have a direct impact on either (Vance, Roenker, Cissell, Edwards, Wadley, & Ball, 2006). Though an age-related decline in functions can be seen in testing facilities, it has been proven that this decline does not significantly affect performance in everyday activities (Salthouse, 1990). Therefore, it is also necessary to assess whether or not physical and mental health status, and self-assessment of visual capacity—which affects driving the most out of the physical and mental functions—directly affect driving compensation behavior.

Additionally, the effect of driving compensation behavior, i.e. whether risk decreases as a result of elderly drivers engaging in driving compensation behavior, is a critical issue. A previous study showed that there were few reports of careful drivers becoming involved in accidents within a month after the end of the study (Salthouse, 1990). Moreover, according to De Raedt & Ponjaert-Kristoffersen (2000), elderly drivers who show driving compensation behavior have better driving skills, and cause fewer accidents, than those who do not compensate. There is, therefore, a possibility that when physical and mental functions have declined, driving compensation behavior can lessen accident risk. However, there has been no research studying exactly how effective driving compensation behavior is as a means to prevent accidents and limiting unsafe driving, and the relationship between driving compensation behavior and accidents cannot be said to be so clear. Looking at accident patterns for automobiles (mopeds or larger), elderly drivers caused a higher proportion of accidents by “not stopping momentarily”, “ignoring traffic lights”, and “blocking right of way”, compared to other age groups; on the other hand, they caused fewer accidents by “violating driving safety obligations” than other age groups (Institute for Traffic Accident Research and Data Analysis, 2011). Furthermore, for violations that resulted in fatal accidents, the most notable characteristic was that while there was a higher percentage of “failure to reduce speed/failure to stop momentarily” (8.1%) than in other age groups, the percentage of elderly drivers “driving over the speed limit” (1.1%) was extremely low. In other words, it may be the case that the violations committed by elderly drivers are not intentional violations, such as breaking the speed limit, but are largely unintentional unsafe actions, caused by inattentiveness at intersections. As this shows, in order to prove the effect of elderly drivers’ compensation behavior, one must examine the relationship between driving compensation behavior, and accidents/violations (which are unsafe actions that could lead to accidents).

Keeping in mind the above, this first aim of this present study is to clarify the background factors related to elderly drivers’ driving compensation behavior. In particular, the investigation will focus on the influence of self-reported driving performance. The second aim of this study is to investigate the relationship between driving compensation behavior and accidents/violations.
2. Method

2.1. Survey participants

Participants of the survey were 277 attendees of the driver’s license renewal course for the elderly, and they participated by filling out questionnaires. Of these, 26 individuals, who were only licensed to drive automated two-wheelers and mopeds, were excluded from the analysis, as well as 14 individuals with missing values. This left 237 valid respondents with Class 1 driver’s licenses (a 85.56% valid respondent rate) as subjects for analysis. Participants in the survey ranged from ages 69 to 86, with an average age of 74.08 (SD = 3.73). Of the total, 204 of the participants were male (86.1%), and 33 were female (13.9%). The average number of years that the participants had been driving was 42.11 years (SD = 10.84).

2.2. Questionnaire structure

2.2.1. Basic attributes and indices of exposure to driving

As basic attributes, we asked for the participants’ age, gender, ownership of a driver’s license, and number of years of driving experience; as indices of exposure to driving, we asked about their frequency of driving (in days per week), and distance driven (in km per week).

2.2.2. Subjective physical and mental well-being

The questionnaire included the following: 1 item (with a 4-point rating scale) concerning subjective physical well-being; for visual impairment, the 3 items (with a 4-point rating scale) from the Japanese version of Strawbridge, Wallhagen, & Shema’s (2007); for mental well-being, the 5 items (with a 6-point rating scale) from the Japanese version of the WHO5 Well-Being Index, the World Health Organization’s simple mental well-being index (Awata, Bech, Koizumi, Seki, Kuriyama, Hozawa, Ohmori, Nakaya, Matsuoka, & Tsuji, 2007). With the items for subjective physical well-being and for mental well-being, higher values indicated better health; with the items for visual impairment, higher values indicated a higher level of impairment.

2.2.3. Self-reported driving performance

In order to measure the self-reported driving performance, we utilized a self-evaluation index for driving, a multiple-item scale consisting of 17 items with 5 points each (Oota, Ishibashi, Oiri, Mukai, & Renge, 2004). We asked the participants to rate their proficiency in 4 elements—namely signaling, steering the wheel, driving at the right speed, and performing checks—in 6 different scenarios: turning left at an intersection; turning right at an intersection; intersections with poor visibility; intersections that require a momentary stop; changing lanes; and driving around curves. Given an instruction saying “Consider how well you think you perform these tasks in your everyday driving, and circle the corresponding number”, participants were asked to rate themselves on a 5-point scale, from ‘1. Cannot do it’ to ‘5. Can do it extremely well’.

2.2.4. Driving compensation behavior

Regarding driving compensation behavior, a countermeasure action questionnaire (Sato,
et al., 2007) was utilized. The questionnaire contained a multiple-item scale consisting of 16 items with 5 points each, and consisted of the following 7 patterns of countermeasures: avoiding multitasking (3 items), such as using cellphones or audio equipment while driving, because of difficulty performing driving-related tasks and other tasks simultaneously; avoiding driving in bad conditions (3 items) such as rain, poor visibility due to fog, or in the night, because of difficulty driving in adverse conditions; avoiding distractions caused by other passenger(s) (3 items) by driving alone, because of inability to focus on driving with others in the car; avoiding choosing difficult routes (2 items), for instance by choosing familiar roads when deciding the route to the destination in advance, because of difficulty driving through unfamiliar routes with complex road/transport environment; avoiding obtaining information from the road environment (2 items), for instance by selecting roads with few traffic lights, because of difficulty obtaining information from traffic lights, signs, etc.; avoiding interaction with other vehicles (2 items), for instance by staying close to the curb before turning left so that motorcyclists cannot squeeze in between, because of difficulty calculating the position of own vehicle in relation to other vehicles; avoiding violating traffic regulations (1 item) by paying particular attention to any traffic signs, etc., due to difficulty spotting traffic signs. With an instruction saying “Consider to what extent you consciously perform the following actions, in your everyday driving”, participants were asked to rate themselves on a 5-point scale, from ‘1. Not at all’ to ‘5. Extremely’. 2.2.5. History of accidents/violations

Participants were asked whether or not they had experienced any accidents (including accidents resulting in property damage) or committed violations (excluding parking violations) in the past three years. Those who answered in the affirmative were asked the number of accidents/violations.

2.3. Procedure

At the end of the license renewal course for the elderly, which was held at a driving school, we explained the details of the survey, and asked willing participants to remain behind and fill out the questionnaire. Participants were given about 30 minutes. As an additional note, this study was conducted after gaining approval from the Ethical Review Committee for Behavioral Research at Osaka University’s Graduate School of Human Sciences.

2.4. Analysis methods

Firstly, in order to assess the influence of background factors such as self-evaluation in prompting driving compensation behavior, hierarchical multiple regression analysis was carried out using a stepwise procedure. Basic attributes, indices of exposure to driving, self-reported physical/mental capacity, and self-reported driving performance, were set as independent variables, and driving compensation behavior as a dependent variable. With regard to gender, males were inputted as 0, and females as 1. Secondly, in order to assess the effectiveness of
driving compensation behavior in preventing accidents and violations, a logistical regression analysis was performed, with driving compensation behavior as an independent variable, and whether or not there had been previous accidents/violations as a dependent variable. Lastly, in order to assess the effectiveness of driving compensation behavior in preventing recurrence of accidents/violations, hierarchical multiple regression analysis was again conducted using a stepwise procedure. This time, driving compensation behavior was set as an independent variable, and the number of accidents/violations as a dependent variable. In this last analysis, as it had been established that the rate of accidents among elderly drivers was high when the distance driven was used as an index of exposure (Ryan, Legge, & Rosman, 1998), distance driven was incorporated into the analysis. Statistical analysis was performed using the SPSS16.0J for Windows (SPSS Inc. 2007) statistics package.

3. Results

3.1. Background factors of driving compensation behavior

Multiple regression analysis was conducted in order to evaluate the effect of background factors of driving compensation behavior. The standard partial regression coefficient of the final model is indicated in Table 1. The results demonstrated various trends: that more people avoid

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Note: β indicates the standard partial regression coefficient. * p < .05, ** p < .01, *** p < .001
driving in bad conditions, and distractions caused by other passenger(s), as they get older; that women tend to avoid driving in bad conditions more; that the less exposed people were to driving, the more they engaged in driving compensation behavior. Subjective physical/mental well-being did not affect driving compensation behavior.

Focusing on self-reported driving performance, the results showed that those who gave themselves a low rating on signaling were more likely to avoid obtaining information from the road environment, and that those who gave themselves a low rating on steering the wheel were more likely to avoid choosing difficult routes. On the other hand, people with higher self-rating on their driving speed were less likely to violate traffic regulations; and people with higher self-rating on checks were more likely to avoid multitasking, choosing difficult routes, and interacting with other vehicles, and less likely to obtain information from the road environment, and to violate traffic regulations. In other words, with signaling and steering the wheel, it was those with lower self-ratings that demonstrated more driving compensation behavior, while with driving speed and checks, it was those with higher self-ratings that demonstrated more driving compensation behavior.

3.2. Relationship between driving compensation behavior and accidents/violations

To show the effectiveness of driving compensation behavior in preventing accidents and violations, the relationship between driving compensation behavior and accidents/violations was examined. The numbers of participants and their experience of accidents within the preceding three years, are as follows: 180 participants reported no accident, and 43 participants reported 1 or more accidents (14 participants once, 21 participants twice, 5 participants 3 times, and 3 participants 4 times). For violations within the preceding three years, the numbers were as follows: 187 participants reported no violations, and 36 reported one or more violations (30 once, 6 twice).

Firstly, the assessment of the influence of driving compensation behavior on accident occurrence, identified no variables that had a significant relation to accident history. Secondly, in the assessment of the influence of driving compensation behavior on violation occurrence, the only variable that had a significant effect on violations was the avoidance of driving in bad conditions (Table 2). It thus became apparent that those who avoid driving in bad conditions tend to commit fewer violations. The above showed that while driving compensation behavior does not affect accident occurrence, it does affect violation occurrence.

Next, an examination was conducted on the relation between driving compensation behavior and number of accidents/violations, in order to elucidate the effect of driving compensation behavior in preventing accident/violation recurrence. According to the results, distance driven did not seem to have any effect, avoiding multitasking was the only countermeasure that affected the number of accidents, and avoiding driving in bad conditions was the only countermeasure that affected the number of violations (Table 3). In other words, it was confirmed that failure to
avoid multitasking had an effect on accident recurrence, and that failure to avoid driving in bad conditions had an effect on violation recurrence. These results, therefore, demonstrated that driving compensation behavior had an effect on both accident recurrence and violation recurrence.

4. Discussion

4.1. Regarding background factors of driving compensation behavior

In order to reveal the background factors of driving compensation behavior among elderly drivers, examinations were conducted with particular focus on the effect of self-reported driving performance.
To address the basic attributes first, the results indicated that the higher the age, the bigger the tendency was to avoid driving in bad conditions and distractions caused by other passenger(s); this confirmed a relationship between age and driving compensation behavior (Table 1). These results also support the findings of Baldock, Mathias, McLean, & Berndt’s (2006) that elderly drivers avoid driving in adverse conditions such as rain or night-time. As for countermeasures to avoid distractions caused by other passenger(s), although Daigo (2006) found that drivers’ awareness of changes in their own driving abilities influenced their choice to drive without other passengers, this study demonstrated that the influence of self-evaluation was not statistically significant, and that age had a greater effect. With regard to gender, the results of the descriptive statistics in this study suggest that on the whole, women have a greater tendency to exhibit driving compensation behavior. The multiple regression analysis results also confirmed that women avoided driving in bad conditions more frequently than men (Table 1). This seems in keeping with Yan, Radwan, & Guo (2007), who posited that elderly female drivers exhibit a prudent attitude to driving, compensating for the decline in their driving skills. Furthermore, in terms of exposure to driving, those with less exposure were found to adopt compensation behavior more, indicating a relationship between low exposure to driving, and driving compensation behavior. Additionally, subjective physical well-being and visual impairment showed no apparent impact on driving compensation behavior. However, the pre-examination correlation analysis indicated that both of these factors had a statistically significant relationship with self-reported driving performance: the lower the appraisal of one’s own physical and mental well-being, the lower the appraisal of one’s own driving skills. Even though there is a link between self-reported physical/mental well-being and driving compensation behavior, no effect showed up in the regression analysis. Therefore, it can be theorized that subjective perception of changes in mental and physical well-being does not influence driving compensation behavior directly, but rather indirectly by affecting self-reported driving performance.

Regarding self-reported driving performance, it has been confirmed to have a considerable influence on the choice of driving compensation behavior. However, with respect to maneuvering the steering wheel and signaling, those with more awareness of the deterioration of their own driving skills were proved to adopt more compensatory behavior (Table 1). On the other hand, with regard to driving speed and checks, those with higher self-assessment scores compensated more. In other words, the relationship between self-rating and driving compensation behavior becomes inverse, depending on the driving skill. Lower self-evaluation had been expected to be linked to compensatory behavior, but the results were contrary to the initial expectations in that lower self-evaluation scores did not necessarily bring about more compensation. One explanation for this is the divergence between self-evaluation and performance (Marottoli & Richardson, 1998). Although the variance between elderly drivers’ self-evaluation and actual performance regarding signaling and steering the wheel has not yet been posited, when it comes to driving speed and checks, the variance between self-evaluations and actual driving performance
has been previously pointed out (Okamura & Fujita, 1997; Renge, et al., 2003; Renge, et al., 2010). Okamura and Fujita (1997) point out that with actions such as backing up and reading signs and markings, there is little discrepancy between self-evaluation and actual practice; however, with checking safety at intersections, there is a large discrepancy between self-evaluation and actual practice. Therefore, there is a possibility that the relation to driving compensation behavior may in fact be different, depending on the size of the discrepancy between self-evaluation and actual driving behavior. Even if there are changes in their driving abilities, drivers may not adopt compensatory measures if their self-evaluations remain unaffected. However, no measurements of actual driving behavior were taken in this study, and so the question of whether or not there are such discrepancies is outside its scope. In the future, it would be beneficial to assess the relationship between self-evaluation and driving compensation behavior, taking into account actual driving performance. The second explanation is a hypothetical situation in which drivers, recognizing the age-induced decline in their driving performance, adopt compensatory behavior, but then later conceive an image of themselves as safe drivers, precisely because they are compensating. Future research will need to track the changes in drivers’ self-perception and driving behavior along a time scale.

As discussed above, this study has demonstrated that in addition to age and gender, self-reported driving performance is a background factor that has an effect on driving compensation behavior. Analysis has confirmed that with signaling and steering the wheel, when self-rating falls, drivers adopt compensatory actions. With respect to driving speed and checks, although there are observable links between high self-evaluation scores and performing driving compensation actions, the precise mechanism underlying this relation requires further assessment.

4.2. The relationship between driving compensation behavior and accidents/violations

This study examined the relationship between driving compensation behavior and accidents/violation occurrence, in order to assess the effectiveness of driving compensation behavior in preventing accidents and violations. With occurrence of accidents and violations, the issue whether or not driving compensation behavior affects accident occurrence was examined; as for the number of accidents and violations, the results indicated characteristics of drivers who repeated accidents and violations more than once.

The results of the study did not confirm the effect of driving compensation behavior affected on accident occurrence; however, the analysis yielded a significant result regarding the number of accidents (Table 3), showing that there is a possibility to prevent accident recurrence by avoiding multitasking. With respect to violations, there were significant results for both occurrence and recurrence (Table 2, 3), which demonstrated that avoiding driving in adverse conditions is a possible way to prevent both the occurrence and recurrence of traffic violations. Although Table 1 showed a link between distance driven and the compensatory measure of avoiding driving in adverse conditions, Table 3 did not show distance driven to be statistically
significant. This suggests that consciously avoiding driving in difficult situations may exert a greater influence than reducing exposure to driving. A possible reason why the occurrence of accidents did not exhibit any influence from driving compensation behavior, is that this study did not account for differences in actual driving proficiency. Among elderly drivers with poor self-reported driving performance, a relationship between compensatory behavior and the occurrence of accidents could be found; however, among those with high or average self-reported performance, there were no significant changes in the occurrence of accidents (De Raedt & Ponjaert-Kristoffersen, 2000). In future research, there is a need to analyze driving compensation behavior while taking into account differences in people’s driving capabilities.

Therefore, although elderly drivers’ unsafe driving actions, brought about by age, can trigger accidents, according to the results of this study, driving compensation behavior could be effective in preventing accidents, and restraining dangerous driving, i.e. violations. This is a significant revelation that the elderly may be able to prevent accidents, by adjusting their driving habits to compensate for changes caused by age.

4.3. Issues and outlook for the future

As regard the type of driving compensation behavior, previous research has established two standards: compensatory behavior that adjusts driving habits, such as avoiding driving in adverse weather, and compensatory behavior that reduces the strain during driving, such as avoiding multitasking (Michon, 1989). This study assessed compensatory behavior by using questionnaires to gather the data, but did not make a clear distinction between the two types. Furthermore, the compensatory actions that reduce the strain during driving, which was handled in this study, included avoiding other passengers, and avoiding obtaining information from the road environment. There is also research that argues that elderly drivers do not tend to cause accidents when driving with another passenger (Padlo, Aultman-Hall, & Stamatiadis, 2005), and research that encourages elderly drivers to drive with other passengers, for the sake of safety (Marshall, Man-Son-Hing, Molnar, Wilson, & Blair, 2007). Additionally, elderly drivers tend to cause more accidents at intersections without traffic lights than at those that have them (Ikeda, Mori, Furuya, Minda, Ueno, Kanto, Funakawa, Yamanaka, Ichihashi, 2004). As evident from these examples, reduced strain and compensatory behavior do not always correspond. Therefore, it will be necessary in the future to clearly distinguish the two types of compensatory behavior (Michon, 1989), after selecting compensatory measures actions that promote safety. Furthermore, this investigation was a questionnaire-based survey, which meant that the answers regarding compensatory actions was a reflection of the individual’s high level of safety awareness, and potentially not of the individual’s actual driving practice. For this reason, it would be preferable to implement a more objective evaluation through observing the drivers in action, especially for on-the-road compensation actions.

The study found that self-reported driving performance was relatively influential as a
background factor of driving compensation behavior. However, this study did not measure actual driving behavior, which may differ greatly from the self-evaluation. This left some points unclear with respect to the process of engaging in driving compensation behavior. In the future, it will be necessary to measure actual driving skills, and investigate the process leading to driving compensation behavior along a time scale. Furthermore, as the results identified compensation behavior that were affected more by aging than by self-evaluation, there may be other age-related factors in play, and not just the process of consciously avoiding driving in strenuous conditions. For example, as individuals grow in age, changes in lifestyle may naturally decrease the need for driving. With this in mind, accounting for the effect of particular lifestyles is another important issue.

Finally, with regard to indices for accidents and violations, this study utilized past accident and violation history. In the future, however, driving compensation behavior needs to be measured in advance, and by conducting follow-up surveys of accidents and violations, the effect of driving compensation behavior in preventing them needs to be assessed. Furthermore, some individuals with low driving skills who had not experienced accidents within the preceding 12 months, had adapted their driving habits more than other better drivers who had experienced accidents in the same period (De Raedt & Ponjaert-Kristoffersen, 2000); such differences between people with different levels of driving skills have been pointed out. With this in mind, future studies will require information about accidents and violations that clarifies what caused the accident, and whether there was an oversight, and take into account differences caused by driving capabilities.

As a prospect for the future, education regarding driving compensation behavior is a possibility. A previous research, which examined the effect of safety education programs on elderly drivers with visual impairments and past experience of accidents (Owsley, McGwin, Phillips, McNeal, & Stalvey, 2004), showed that education was able to teach attendees to avoid driving in strenuous conditions. As driving compensation behavior can be adapted through education, there are high hopes for studies of methods of studying and teaching that effectively leads to the prevention of accidents.

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