Safety Education Method for Older Drivers to Correct Overestimation of Their Own Driving

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Abstract: Older drivers tend to overestimate their driving ability. This overestimation makes it difficult for them to drive safely. We considered why older drivers formed their overestimation and proposed a safety education method to correct it. The proposed method includes simulated experiences of collisions and near-miss events and reflection on their driving at the events. The proposed method was found effective for older drivers to correct their overestimation based on a participant experiment. However, compared to non-older drivers, the older drivers corrected their overestimation less. To investigate the reasons for this result, we analysed the method's effectiveness on older drivers. Analysis results suggest that the optimistic interpretation of their own driving discourages older drivers from correcting their overestimation.

1 INTRODUCTION

In many countries, the number of older licenced drivers is rapidly increasing (Newnam et al., 2020). Especially in Japan, the number of older licenced drivers has increased ten times in the last ten years, and the ratio of traffic accidents caused by them has increased drastically (Japanese police department, 2019). Therefore, traffic accidents by older drivers have become an urgent issue that must be solved.

Countermeasures to prevent traffic accidents by older drivers include promoting the return of driver's licences, developing autonomous driving technology or advanced driver-assistance systems, and driver education. However, driving a car is essential to live for some older people (Yanagihara 2019). Thus, promoting the return of their licence greatly impacts their quality of life. Moreover, even if autonomous driving technology and driver-assistance system are used, drivers still need to drive most of the time on their own for now. Accordingly, improving the effectiveness of safety education is important to reduce traffic accidents by older drivers.

One of the important aspects of safe driving for older drivers is self-assessment of their own driving. Although the decline in driving ability may be inevitable due to cognitive and physical decline with age, if older drivers can correctly identify their driving, older drivers can drive safely (Anstey et al., 2005). Meanwhile, most older drivers are overconfident in their driving ability (Ota et al., 2004). Therefore, safety education, which lets older drivers estimate their real driving ability and correct their overestimation, is important for them to drive safely.

The overestimation of drivers is said to be formed by their daily driving experience. Concretely, drivers do not often encounter accidents or near-miss events, even if they drive dangerously (Matsumura, 2011). Moreover, if drivers experience collisions or near-miss events, they often do not reflect them in their driving by considering them exceptions or blaming other traffic factors (Job, 1990). In other words, drivers form their overestimation because they have few opportunities to correct their overestimation in their daily driving, and even if they face such events, the events alone do not lead them to correct them. Therefore, safety education considering this formation process of overestimation is required.

This study proposes a safety education method that is effective for older drivers to correct their

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overestimation of their own driving. To achieve this goal, we considered why drivers formed their overestimation, developed methods to correct it, and verified and discussed the method's effectiveness for older drivers.

This paper is organized as follows. Section 2 describes and proposes the education method which aims for older drivers to correct their overestimation. Section 3 describes the experimental method to verify the effectiveness of the proposed method for older drivers. Section 4 describes the experiment's results showing whether the proposed method was effective. Section 5 discusses the effectiveness of the proposed method. Lastly, Section 6 summarizes the findings of this study.

2 EDUCATION METHOD

In this study, two points that form overestimation in driving were focused on: lack of experiences of collisions and near-miss events and difficulty in reflecting such experiences in their own driving. Thus, an education method was developed which meets the following two requirements:

- Enable drivers to experience collisions and near-miss events
- Enable drivers to reflect collisions or near-miss events in their own driving

The following two sections (Sections 2.1 and 2.2) describe the method that satisfies the requirements.

2.1 Experience Collisions or Near-Miss Events

A driving simulator was used to have participants experience collisions and near-miss events because simulators can reproduce such events safely. The scenario where drivers pass through a narrow street with blind corners and pedestrians running out from the corners was chosen as the simulation scenario (Figure 1). This scenario was chosen because older drivers are more likely to cause accidents in this scenario.

When using simulators in education, it is important to make the participants think that the simulated experience is reasonable and can imagine their problems (Nakamura, 2007). First, to make the participants think that the simulated collisions or near-miss events are reasonable, participants are given the experience of collisions or near-miss events based on their own driving by the following steps.

Figure 1: A sample scenario reproduced inside the driving simulator that the participants experience.

1. Participants drive a simulator course without pedestrians running out from the blind corners, and their driving behaviour is recorded.
2. Participants watch the driving behaviour recorded in the 1st step from the first-person's perspective using the simulator, and a pedestrian runs out from a certain blind corner.

Pedestrians running out from the blind corners were set to start moving 1.2 seconds before the vehicle reached the pedestrian to reproduce a risky situation. By having the participants experience the events based on their own driving behavior, they were likely to think that the collisions or near-miss events could happen in their real driving.

Second, to enable the participants to imagine what is problematic through the simulated experience, we focused on what task is done during driving and to simplify the driving task. When drivers sense danger in the traffic environment, they first detect hazards that may cause danger (Hazard perception) and estimate the risk of the hazard (Risk perception) (Shino et al., 2012). Thus, we created two types of scenarios that focus on each of them respectively to make the driving task simple. In the hazard-perception scenario, an alarm rings before the pedestrian runs out so that the participants can focus on detecting hazards by estimating the risk of hazards high compulsory. In the risk-perception scenario, a red mark was placed above all hazards that may run out so that the participants could focus on estimating the risk of hazards by enabling compulsory detection of hazards. In this way, when the participants experienced collisions or near-miss events in the simulated driving, they were promoted to consider the cause of the events and reflect on the problem of their driving behaviour. The method's effectiveness in giving participants experience of collisions and near-miss events by dividing into these two scenarios has already been validated in our previous work (Nishimoto et al., 2021).

2.2 Reflect Collisions or Near-Miss Events in Their Own Driving

In this study, the coaching method, which is sometimes used in driving education, was adopted.

Unlike teaching, this method encourages students to realize their driving problems voluntarily through a dialogue about their driving between them and their coaches. This method was proven effective in correcting self-assessment (Renge et al., 2010). Thus, we let the participants speak with the experimenter about the experiences of collisions or near-miss events in the simulator based on this method to promote them to realize their driving problem. To learn lessons that can be applied in real life from simulated near-miss events, Nakamura (2007) points out that the following three points are important:

(a) Whether the students recognize the simulated experiences as a near-miss event
(b) Whether the students understand the cause of the near-miss event
(c) Whether students acquire measures that can be used in actual situations

Based on these points, in this study, we had the participants answer the following three questions just after the simulated experiences of collisions or near-miss events to promote them to learn lessons from experience:

(a) How did you recognize this situation with a pedestrian running out from a blind corner?
(b) What do you think caused this collision or near-miss event?
(c) Have you ever experienced a similar situation in the past?

This coaching method lets the participants think and answer these questions voluntarily. However, for question (b), the experimenter sometimes assists them in thinking about the cause of the experience (e.g., “Did you detect the pedestrian fast?” or “How was the speed of the car?”). In addition, for question (c), the experimenter encouraged the participants to recall and answer concrete situations if they had a similar experience in the past.

3 EXPERIMENT METHOD

A between-subjects design experiment was conducted to verify the effectiveness of the education method for older drivers proposed in the previous section. The method’s effectiveness was evaluated regarding the change in self-estimation (overestimation) and on-road driving behaviour. The details are described in the following sections. This experiment was conducted with the approval of the Ethics Committee of the University of Tokyo.

3.1 Participants

The participants were 20 older participants and 20 non-older participants for comparison. The older participants were recruited from a human resource centre that offers a temporary jobs to older residents in Kashiwa, Chiba, Japan. All of them were 70 years or older (mean age = 74.1, SD = 3.0), driving routinely (mean number of days per week to drive = 5.5, SD = 1.9), and had no cognitive impairment. The non-older participants who live or work near the Kashiwa Campus of The University of Tokyo were recruited. They aged between 26 to 46 years (mean age = 41.5, SD = 6.0) and driving routinely (mean number of days per week to drive = 5.3, SD = 2.3).

3.2 Equipment

Figure 2 shows the driving simulator used in this study. The scenario inside the simulator was created with the simulator software D3sim (Mitsubishi Precision Co., Ltd.). During the simulator driving, the eye movements of the participants were measured with a glass-type eye-tracking device (Tobii Pro Glasses 2, Tobii AB). This eye movement data is used to identify when the participants detected the pedestrian running out from the blind corners in the simulator scenario.

An experimental vehicle equipped with a data recorder was used to evaluate the on-road driving behavior. The recorder recorded vehicle behaviour (e.g., position, speed, acceleration), driver operation (e.g., steering wheel angle, pedal status), and images acquired from cameras equipped inside the vehicle (e.g., vehicle front view, driver’s face).

3.3 Outcome Measures

To verify the effectiveness of the proposed method, we evaluated the change in self-estimation and on-road driving behaviour. Moreover, to examine whether the proposed education method was effective for the participants to correct their overestimation, their reflection on the simulated experiences was also evaluated. To assess these, we adopted the following three outcome measures.

3.3.1 Self-Estimation

To evaluate the change in self-estimation, we made a questionnaire with the following four items. Each item was scored on a 7-point Likert scale.

1. Are you aware enough of hazards during driving?

2. Are you capable of detecting hazards during driving?
3. Are you able to sufficiently estimate risks of hazards during driving?
4. Are you driving safely overall?

Figure 2: Appearance of driving simulator.

In addition, the participants were ordered to score each item from absolute and relative perspectives because drivers often overestimate themselves compared with other drivers (Matsuura, 1999). An average of the eight (four items * two perspectives) scores was set as the self-estimation score. When the participants scored, they were shown the video of their on-road driving before the education (described in the next section) and evaluated that driving to clarify what driving to evaluate. During the on-road driving before the education, a driving instructor sat in the passenger seat and answered the same questionnaire based on the driving of each participant. Using the two scores, we set the overestimation score, which is calculated for each participant by subtracting the instructor's score from the participant's score to evaluate the change in self-estimation.

3.3.2 On-Road Driving Behaviour

An on-road driving experiment was conducted before and after the education to evaluate the changes in on-road driving behaviour. The participants drove a course set near the campus, which included narrow streets and intersections with blind corners like the simulator scenario.

As a target scenario inside the on-road driving to evaluate the change in driving behaviour, we adopted a scenario where the participants drive through a stop intersection with a blind corner (Figure 3). At stop intersections, it was found that older drivers tend to drive faster near the stop line and confirm less towards the left and right when passing the intersection compared to middle-aged drivers (Hashimoto et al., 2010). Thus, in this study, we set the speed when passing the stop line and the ratio of time spent to confirm towards the left and right when passing the intersection (confirmation time ratio) as measures to evaluate on-road driving behaviour.

Figure 3: Appearance of target scenario in on-road driving: Stop intersection with blind corners.

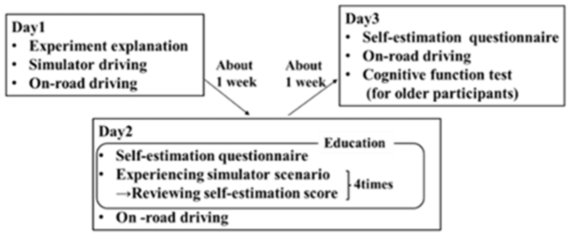

Figure 4: Experimental procedure.

3.3.3 Reflection on the Simulated Experiences

To evaluate whether the participants reflected the simulated experiences in their driving, we adopted the following three scores: Recognition, Understanding, and Acquisition. Each was scored based on the answers to the questions (a) – (c) asked just after experiencing each simulated scenario mentioned in Section 2.2.

<u>Recognition score (Answer to question (a))</u>

- 0.0: Recognize it as safe
- 0.5: Recognize it as a near-miss event
- 1.0: Recognize it as a collision

<u>Understanding score (Answer to question (b))</u>

- 0.0: Do not answer driving problems
- 0.5: Answer driving problems with assist
- 1.0: Answer driving problems voluntary

<u>Acquisition score (Answer to question (c))</u>

- 0.0: Do not answer past experiences
- 0.5: Only answer the presence of past experiences.
- 1.0: Answer the concrete situation of past experiences.

3.4 Procedure

The experiment was conducted over three days, and each day was spaced for about one week (Figure 4). On Day 1, the participants are explained about the nature of the experiment, drive the simulator to create customized risky scenarios for education, and drive on roads. On Day 2, the participants experience the proposed education method and drive on roads again after the education. Finally, on Day 3, the participants answered the self-estimation questionnaire, drove on roads, and underwent some cognitive function tests, which were conducted only on older drivers.

In the education, the participants answer the self-estimation questionnaire and experience the scenarios in the simulator. Each participant experienced four scenarios (two hazard-perception scenarios and two risk-perception scenarios). First, the participants answer the self-estimation questionnaire before they experience any scenarios. Second, they experience two hazard-perception scenarios, and after each scenario, they answer the questionnaire and review their self-estimation score about detecting hazards. Third, they experience two risk-perception scenarios, answer the questionnaire, and review their self-estimation score about estimating risk similarly. Finally, after experiencing all four scenarios, answer the questionnaire again and review their self-estimation score about safety awareness and overall safety of their driving behaviour.

4 RESULTS

4.1 Self-Estimation

The overestimation score decreased significantly after the education for both older and non-older participants (Older: $p < 0.05$, non-older: $p < 0.01$) (Figure 5). Moreover, the mean overestimation score decreased after the education, and this effect continued one week after the education. Therefore, the effectiveness of the proposed education was confirmed. However, compared to the non-older participants, the decrease in mean overestimation score of older participants between before and after education was small (Older: 0.08, non-older: 0.22). In addition, the number of older participants who did not correct their overestimation score was more than the non-older participants (Older: 6 participants, non-older: 4 participants). Thus, we confirmed that the proposed method was less effective for older than non-older participants.

4.2 On-Road Driving Behaviour

The older participants improved both driving measures, where the speed at the stop line decreased and the confirmation time ratio increased after the education. Moreover, the confirmation time ratio improvement continued one week after the education, although the improvement in speed did not (Figure 6). Therefore, the proposed education was effective in terms of on-road driving behaviour, reducing unsafe behaviour at stop intersections.

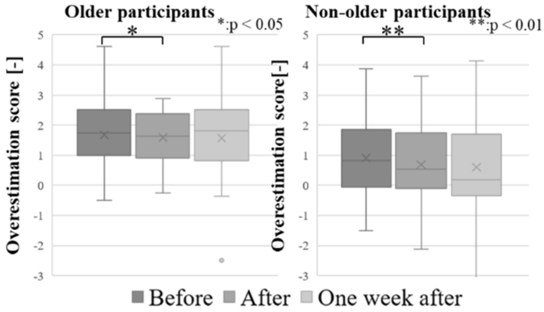

Figure 5: Change in on-road driving behaviour of older participants.

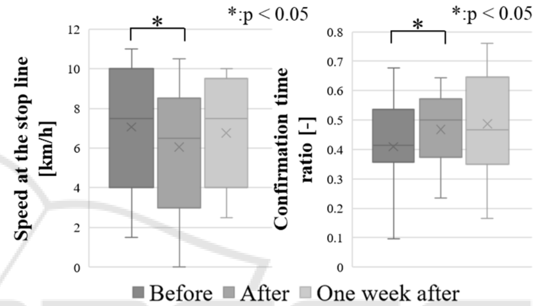

Figure 6: Change in overestimation score of older and non-older participants.

4.3 Reflection on the Simulated Experiences

The participants tended to correct their overestimation if they recognized the simulated experience and understood the cause of it. We plotted the answered frequency of each combination of recognition and understanding scores and classified them into two groups according to whether the participants corrected their overestimation score after they answered or not: correcting and non-correcting (Figure 7). The acquisition score was excluded from the plot because it was found that the score had less to do with the correction of overestimation. This plot showed that recognizing the situation as near-miss events or collisions and understanding the cause of the situation was essential for the participants to correct their overestimation. Therefore, it was shown that the aim of the proposed method was appropriate, and if the older participants behaved as expected, they were likely to correct their overestimation. On the other hand, we found that older participants did not recognize the situation as near-miss events and collisions and did not reflect such experiences in their own driving.

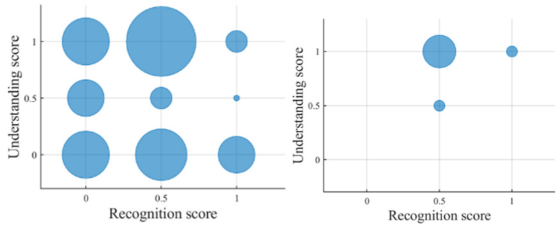

Figure 7: Answered frequency of the combinations of recognition and understanding scores (Left: non-correcting group, right: correcting group).

5 DISCUSSION

The results show that the proposed education method effectively corrected the older participants' overestimation. However, it was also found that the older participants were less likely to correct their overestimation and often did not reflect the simulated experiences in their driving, contrary to our expectations. Thus, to reveal why the proposed method was ineffective for some of them and how the effectiveness of the education could be improved, we analysed the participants who did not correct their overestimation and conducted an additional survey.

5.1 Analysis of Non-Correcting Participants

To investigate why the non-correcting participants did not correct their overestimation, we classified the older participants into correcting and non-correcting groups according to whether they corrected their overestimation score and investigated the differences.

First, we analysed the difference of whether each group recognized the situation as near-miss events and collisions or not. By comparing the recognition score in each group, the non-correcting group was less likely to recognize the situation as a near-miss event than the correcting group (Table 1). Thus, it was found that the method to enable participants to experience near-miss events and collisions did not work as expected for the non-correcting group. We further analysed the eye movement data to reveal the reason for this. In the scenarios, pedestrians appeared 1.2 seconds before a collision uniformly. Thus, if the participants can detect the pedestrian earlier, they can easily avoid it. To measure this, we defined the detecting time as an elapsed time after the appearance of the pedestrian to when the fixation point overlapped the pedestrian. We compared the detecting time between the two groups and found that the average detecting time of the two groups is alike

Table 1: Comparison of recognition score percentage between correcting and non-correcting groups.

Group	Safe (0.0)	Near-miss (0.5)	Collision (1.0)
Correcting	25%	58%	17%
Non-correcting	63%	25%	12%

(Correcting: 0.35 seconds, non-correcting: 0.34 seconds). In other words, detecting time did not influence the recognition of the situation. To make clear why the non-correcting group did not recognize the situation as a near-miss event, we plotted the detecting time corresponding to the "safe (0.0)" and "near-miss event (0.5)" of both groups (Figure 8). This figure showed that the non-correcting group never answered "near-miss event" if the detecting time was less than 0.3 seconds. Moreover, only the non-correcting group answered "safe" if the detecting time was more than 0.4 seconds. This result shows that each group interpreted the simulated experiences differently. The non-correcting group tended to feel the experiences as safe, and the correcting group felt as a near-miss event.

Second, we analysed whether the correcting and non-correcting groups reflected the experiences differently after the near-miss or collision experiences. To investigate this, we analysed the difference in understanding scores between the two groups when the recognition score was 0.5 or 1. This analysis revealed that the correcting group tended to answer driving problems such as speed and gaze. In contrast, the non-correcting group tended to answer the problems of other factors like the simulator without admitting their own driving problems (Table 2). Thus, the non-correcting group tended to be reluctant to interpret their own driving problems, although the correcting group interpreted them relatively easily.

The analysis showed that even though the non-correcting participants were given the opportunities to have near-miss and collision experiences and to reflect on their driving behaviour, they interpreted them optimistically and did not correct their overestimation. Older drivers are known to have the characteristics to interpret the effects of their driving optimistically (e.g., Ferring et al., 2015). Such optimistic characteristics may have prevented the older participants from correcting their overestimation and considering it may be important to improve the effectiveness of the education. Therefore, it was suggested that it was required to reveal the impacts of such an optimistic interpretation on the older participants and correct overestimation.

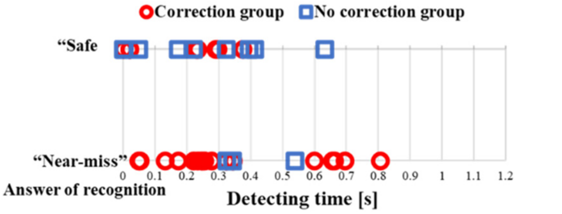

Figure 8: Detecting time corresponding to "safe (0.0)" or "near-miss (0.5)" answers of correcting and non-correcting groups.

Table 2: Comparison of understanding score percentage between correcting and non-correcting groups.

Group	Not driving problems (0.0)	Driving problems (0.5, 1.0)
Correcting	50.0%	50.0%
Non-correcting	16.6%	83.3%

5.2 Additional Questionnaire Survey

The analysis of the non-correcting group suggested that the optimistic interpretation impacted correcting overestimation. We investigated the optimistic characteristics of the older participants through an additional questionnaire survey to consider how to improve the effectiveness of education.

5.2.1 Method

An additional questionnaire survey was conducted on the older participants to investigate whether the non-correcting group has an optimistic view of their driving behaviour. In accordance with the self-estimation score, we adopted two questionaries that ask optimistic views from an absolute and a relative perspective. When they did not correct their overestimation from an absolute perspective, they may not have been able to admit their driving ability declining with age. In a previous work (Ferring et al., 2015), drivers were asked how much they agreed with positive stereotypes (e.g., more experience, more reasonable) and negative stereotypes (e.g., more dangerous, more error-prone) about older drivers in a five-point scale questionnaire. The more the drivers were older, the more likely they were to agree with positive stereotypes and disagree with negative stereotypes. This indicates that older drivers tend to interpret the decline of their driving ability optimistically. Therefore, we adopted the questionnaire used in this Ferring's work and had the participants answer it. We verified the optimistic interpretation of their driving ability and considered whether such an interpretation affected the correction of overestimation.

When the participants did not correct their overestimation from a relative perspective, they may not have been able to accept being poor in their driving ability compared to others. A previous work (Gosselin et al., 2010) revealed that when the older drivers assessed the risk of a car crash in other older and middle-aged drivers in a five-point scale questionnaire, they answered that the risk is higher in both drivers compared to themselves. This indicates that older drivers are likelier to interpret their accident risk than others optimistically. Therefore, we also adopted Gosselin's questionnaire and had the older participants answer it.

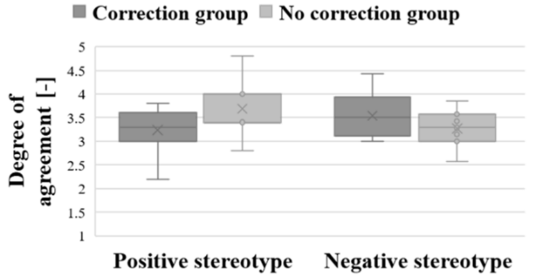

Figure 9: Results of the Ferring's questionnaire.

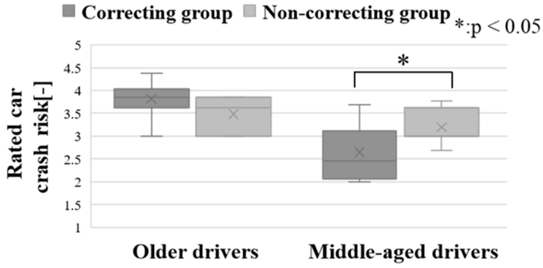

Figure 10: Results of the Gosselin's questionnaire.

5.2.2 Results and Discussion

As for the stereotypes about older drivers, the non-correcting group tended to agree with the positive stereotypes and disagree with the negative stereotypes compared to the correcting group (Figure 9). As for the crash risk, the non-correcting group assessed that the risk in middle-aged drivers was higher compared to the correcting group (Figure 10). These results showed that the non-correcting group tended to interpret their driving and especially the decline of it with age optimistically. This suggests that their optimistic interpretation influenced correcting their overestimation, and improving such interpretation was the key to correcting their overestimation.

In this study, the non-correcting group interpreted the decline in their driving optimistically, which meant they were not anxious about their driving behaviour. This may have made them indifferent to the education and did not motivate them to change their belief. This indicates that enhancing participants' motivation for education may effectively correct overestimation. In educational technology, Keller's ARCS model is known as a measure to enhance students' motivation for educational material. According to this model, improving attention and relevance to the material is important for students to be encouraged to try it (Keller, 1987). In this study, the non-correcting group did not think their driving needed improvement, which may have impeded them from having attention and relevance to the education. Therefore, enhancing attention and relevance to the education may be the next step to improve the effectiveness of our method.

5.3 Limitations

There are some limitations in this study. First, the sample was not large and biased toward active and healthy males. It is said that male and female older drivers have different ways of thinking toward their driving (Ferring et al., 2015). Thus, the effectiveness of the proposed method for older female drivers may differ. Second, we did not investigate the long-term effects of the education, although we checked one week after the education. We need to continue investigating the education's effectiveness because long-term assessment is important in safety education. Third, the target scenario in the simulator and on-road driving was limited to narrow streets and intersections with blind corners. Older drivers are also likely to cause accidents in other scenarios. It may not be obvious that the participants could reflect on their driving behaviour.

6 CONCLUSIONS

This study proposed an education method to correct the overestimation of older drivers. This method enabled the participants to experience near-miss events or collisions and reflect them in their own driving. As a result, older people could correct their overestimation with the method; however, their correction was less compared to non-older people.

Further analysis and an additional questionnaire survey revealed that people who did not correct their overestimation with the method tended to interpret the simulated experiences and their driving ability optimistically. It is suggested that this optimistic interpretation of their driving discouraged them from correcting their overestimation.

Enhancing the motivation for education is suggested to be the key to improving the effectiveness of the education method. The method of enhancing motivation is fully researched in educational technology. Therefore, the next step to improve the method's effectiveness is to refer to works in educational technology and consider ways to enhance the motivation of older participants.

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