Acceptability of a Proactive Braking Intervention System by Elderly Drivers Using an Actual Vehicle

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ABSTRACT: To evaluate the acceptability by elderly drivers of a proactive braking intervention system, we conducted an experiment using an actual vehicle, which could control velocity autonomously, on a test track. After driving the experimental vehicle, the participants evaluated acceptability from various aspects by subjective questionnaires. From the results of 21 elderly drivers, we confirmed the following tendencies: partly negative evaluations for reactive factors, positive evaluations for comprehensive factors, and positive evaluations for total acceptance. In addition, from the results of the trials in which we used head-up display, we confirmed that an information sharing system could improve the evaluations of reactive factors.

KEY WORDS: Safety, Protection of Older People, Driving Support / Acceptability, Proactive Collision Avoidance, Head-Up Display [C1]

1. Introduction

As a countermeasure to the recent increase in traffic accidents caused by elderly drivers, our research project(1) aims to develop a driving support system based on automated driving technologies. Evaluations and improvement of the acceptance for such a system are as important as technological developments of necessary components such as algorithms(2) of vehicle control. In our previous study(3), we examined the acceptance of proactive intervention systems, which intervened the operations of the driver and switched the authority of the vehicle control, with respect to both steering and braking operations, to avoid potential risks on a road. Regarding the braking intervention, we confirmed that elderly drivers accepted the examined system to a certain degree. In addition, we confirmed that reducing the uncertainty of the functionality of the intervention system was key to improving the acceptance furthermore. Thus, in another previous study(4), we proposed an information sharing system using a Head-Up Display (HUD), and confirmed the effectiveness of the proposed system. However, experiments in the abovementioned previous studies were conducted by using a driving simulator, in which the subjective reality of driving was not perfect. Therefore, in this study, we implemented the prototype of the proposed system in an actual vehicle, and conducted the evaluation test on an actual course including both potentially and apparently dangerous scenes. Furthermore, we aimed to examine the acceptance, and confirm the mechanisms of acceptance and refusal, of the system in the real world by elderly drivers.

2. Proactive Braking Intervention System

2.1. Target situations for proactive braking intervention

Generally, the driving process for human drivers consists of repetitions of perception, recognition, judgement and operation. In contrast to normal drivers, the decline in physical functions of elderly drivers due to aging sometimes causes delays in each process; furthermore, it sometimes results in dangerous driving situations(5). In addition, existing research(5) have pointed out that deviations between subjective and objective standards for safe driving, due to driving experience over the ages, might sometimes result in unsafe driving. In this study, to compensate for such delays in the operation process and deviations of risk evaluations, we aimed to develop a driving support system composed of a dual system with human drivers. Fig. 1 shows the conceptual schematic of the system proposed in our previous studies. If the operations of the human drivers are not adequate in some situations, this system actively intervenes the operation by switching the authority of vehicle control. This is the basic concept of the intervention system for realizing safe driving.

In this study, we assumed that this system fulfilled its role both in the potentially dangerous situations where elderly drivers failed to confirm the risk of driving situations, and in the apparently dangerous situations where the necessary operations of elderly drivers were delayed. To be more precise, as in the former case, we assumed the potentially dangerous situation where the pedestrians might rush out from an occluded area due to a narrow alley and a parked vehicle. With regard to the latter case, although
there are various cases to consider in actual driving scenes, we assumed the moment of deceleration before negotiating a curve as an example. Regarding the characteristics of the driving situations, whether it is potentially or apparently dangerous might affect the evaluations for the system. Thus, in this study, we conducted evaluation experiments by comparing three scenes: scene 1 as the potentially dangerous situation, scene 2 as the apparently dangerous situation, and scene 3 as the combined dangerous situation, whose details are explained in the following chapter.

2.2. Acceptability of proactive braking intervention system

Regarding the existing advanced driver assistance systems, existing research sometimes evaluated their acceptability based on the subjective appropriateness of the system. For example, Itoh et al.(6) asked following two questions when they evaluated the acceptability of a semi-autonomous forward obstacle collision avoidance system.

- “To what extent do you think your collision avoidance capability is improved with the aid of the system?”
- “To what extent do you think the system’s maneuvers were appropriate?”

Because these types of evaluation focused on normal drivers with sound driving abilities, there was a premise that the drivers could adequately evaluate the appropriateness of the driving assistance system. However, because we focused on elderly drivers who do not necessarily possess sound driving abilities, we could not follow the existing method for evaluation. For example, in the case that an elderly driver with declined driving abilities considered the functionality of the assistance system as inappropriate, we cannot judge whether it came from the performance of the assistance system or from the ability of the evaluator. Thus, we needed a different perspective from existing methods to evaluate the acceptability of an advanced driver assistance system for elderly drivers.

In our previous study(3), we focused on the viewpoint of desire to introduce an advanced driver assistance system into their own vehicles for evaluating the acceptability of the system. In addition, to discuss the mechanism of acceptance and refusal of the system, we evaluated the system from the following three viewpoints. Fig. 2 shows the conceptual schematic of hierarchical sources of total acceptance.

- Reactive acceptance and refusal: Evaluation based on the instinctive factor during use of the system.
- Comprehensive acceptance and refusal: Evaluation based on sufficient understanding of the merits and demerits of the system.
- Reflective acceptance and refusal: Evaluation based on the self-image as the owner of the system among others and the society.

As for the proactive braking intervention, we confirmed that the comprehensive factors were positively evaluated; further, it led the positive evaluation of the total acceptance of the system.

Although we confirmed the abovementioned findings in our previous study, the activities still remained initial exploratory trials. For example, because the findings were limited by the premises of the previous study, the relationship between reactive acceptance and comprehensive acceptance is still unclear. In our previous study, because we conducted the evaluation using a driving simulator that could not perfectly represent the acceleration and driving feeling, the evaluation regarding the reactive acceptance might not be sufficient. Furthermore, because we aimed to confirm the initial evaluation without providing sufficient preliminary explanations regarding the system in our previous study, there are some unsolved issues on the mechanism of comprehensive acceptance. Thus, in this study, we aimed to evaluate the total acceptance by providing sufficient knowledge about the system, and using an actual test vehicle on an actual test course. In addition, because of the disproportionate focus we placed on the individual characteristics of the drivers in our previous study, there were not sufficient discussions to extrapolate general trends. Thus, in this study, we aimed to discuss from the viewpoint of general trends, although representativeness of the participants would be limited. In other words, we mainly focused on the mechanisms of reaction and comprehension because the mechanics of reflection were attributable to individual characteristics. This was the first purpose of this study.

2.3. Information sharing system using HUD

Because reactive acceptance was not good in our previous study(3), we proposed an information sharing system using a HUD in our subsequent study(4). In contrast to existing information
providing systems that aimed to make drivers’ behaviors appropriate by using an alert functionality, our proposed system aimed to have the driver accept the proactive braking intervention system by gradually gaining an understanding of the status and behavior of the system. Thus, we called our proposed system not as “warning system” but as “information sharing system”\(^6\). In addition, we designed the visual content with this purpose in consideration. Moreover, in another previous study\(^7\), we confirmed that the information sharing system could improve acceptability during a proactive braking intervention. However, because we conducted the evaluation experiment using a driving simulator, we did not adequately confirm the effectiveness of the information sharing system, in terms of the factors for reactive refusal, such as impatience and annoyance caused by the actual behavior of the proactive braking intervention. In summary, we needed to confirm whether the information sharing system could reduce actual impatience and annoyance of elderly drivers in the real world. Thus, in this study, we also aimed to confirm this through the experiment using an actual vehicle on the actual test course. This was the second purpose of this study.

2.4. Implementation of proactive braking intervention

Fig. 3 shows the experimental vehicle used in this study. This experimental vehicle is equipped with a computer that can control longitudinal acceleration. Regarding lateral control, the drivers operated the steering wheel by themselves. In this study, because repeatability of the trials was necessary, we implemented both an acceleration and deceleration system by using a digital map and a dead reckoning based on an inertial measurement unit (IMU) and rotation pulse of rear wheels. To be more precise, in normal situation, the system accelerates the vehicle to approximately 30 km/h. In the dangerous situations such as occluded areas, the system decelerates the vehicle and reaccelerates after passing through the target situations.

Fig. 3 Experimental vehicle

The original purpose of the proactive braking intervention system was to support drivers in potentially dangerous situations. However, keeping an unfamiliar vehicle at a constant velocity was difficult for elderly drivers to a certain degree; furthermore, there was the possibility that the experimental participants would neglect the evaluation of the braking intervention, which was the main task of the experiment. Thus, we constructed the experimental system to have the task of controlling not only the deceleration but also the acceleration as well as maintaining a constant velocity. The assumed and prospective purpose of the system in this study was not the autonomous driving but the driving support system. Thus, to keep a little sense of agency, we set up the system that the participant’s operation of the right winker started the vehicle control.

2.5. Implementation of information sharing system

Fig. 4 shows the HUD used in this study. Although we assumed the large HUD mounted on the windshield in the previous experiment using a driving simulator, such HUD had not been yet commercialized. Thus, we used this comparably smaller commercial HUD; however, this meant that we could not display some of previously proposed visual contents in this HUD.

Fig. 4 HUD for information sharing system

In this study, we divided the target situation into three parts: before intervention, during intervention, and after intervention. Fig. 5 shows the conceptual schematic of the parts. First, before intervention, the system displays the visual content that notifies the reason of braking intervention. Thereafter, during intervention, the system displays the visual content that notifies the control state of deceleration. Finally, after intervention, the system displays the visual content that notifies the control state of reacceleration. Fig. 6 shows the examples of corresponding visual contents for each part. Regarding center one, the red inverse triangle with white small inner triangle indicates the “slow down” in Japan. In addition, the Chinese characters in the center of the inverse triangle also indicate the “slow down” in Japan. The yellow side bars, which are becoming shorter in accordance with the progress of deceleration, roughly indicate the duration of the braking intervention. To make the participants easily notice the visual contents, the system beeps when it displays the visual contents.

Fig. 5 Situations for providing visual contents during proactive braking intervention

Fig. 6 Examples of visual contents
3. Experiment

The following protocol was approved by the institutional review board for human studies of the University of Tokyo. We explained the protocol of the experiment to the participants, and obtained written informed consent from them.

3.1. Experiment participants

In this study, we recruited 21 healthy elderly drivers who were 69 to 75 years old (M = 72.0 years; SD = 2.0 years) as our experiment participants. They had a driving license for a period between 35 and 56 years (M = 49.7 years; SD = 5.6 years). Their average frequency of driving was 5.9 days per week.

Before the experiment, we asked about the ownership of the following advanced driver assistance systems.

- Forward vehicle collision warning system (FVCWS)
- Automatic emergent braking system (AEB)
- Lane keeping assist system (LKAS)
- Adaptive cruise control system (ACC)

Only one participant answered that his own vehicle was equipped with FVCWS and AEB. On the contrary, no participants answered that their own vehicles were equipped with LKAS and ACC.

3.2. Experimental procedure

The procedure of this experiment was as follows.

Proc. 1: Explanations of the system and the experiment.
Proc. 2: Trials on course 1 including scenes 1 and 2.
Proc. 3: Trials on course 2 including scene 3.
Proc. 4: Free description questionnaires.

In addition, the following shows the detailed procedure on course 1. The procedure is the same for course 2.

Proc. 2-1: Practice of manual driving on the course.
Proc. 2-2: First experience of the proactive braking intervention without information sharing system on the course.
Proc. 2-3: Second experience of the proactive braking intervention without information sharing system on the course.
Proc. 2-4: Multiple-choice questionnaires.
Proc. 2-5: Experience of the proactive braking intervention with information sharing system without beep sound on the course.
Proc. 2-6: Experience of the proactive braking intervention with information sharing system with beep sound on the course.
Proc. 2-7: Multiple-choice questionnaires.

Because the experience of the proactive braking intervention without information sharing system were conducted prior to that with information sharing system, the evaluation result might be affected by the experimental order. To be more precise, in this experiment, accustomization toward the proactive braking intervention might happen by the order effect; besides, it might affect the evaluation results. However, we set the experimental order as above described because the evaluation regarding the comprehensive factors should be conducted before the experience with information sharing system. Thus, to handle the possibility of the order effect, we took two measures. First, to reduce the order effect as much as possible, we repeated the experience of the proactive braking intervention without information sharing system two times, and conducted the evaluation after the second experience. Second, to grasp the degree of the order effect, we uniformed the possibility of the order effect for scenes 1 and 2. Due to the arrangement of the abovementioned experimental order, the degrees of the order effect were expected to be equivalent for both scenes if the order effect happened. Through the comparisons of the results for both scenes, we thought that we could grasp the degree of order effect.

3.3. Experimental course

These experiments were conducted on the test course of Japan Automobile Research Institute. Fig. 7 shows the overhead view of course 1. In the first half of the course, we placed barriers to set up the occluded T-junction. Hereafter, we refer to this area as scene 1. This scene reproduced the potentially dangerous scene where a pedestrian might rush out from the occluded area. From approximately 40 m before the end-point of the occluded T-junction, the vehicle started to decelerate, and the velocity at the end-point of the occluded area was approximately 5 km/h. Fig. 8 shows the appearance of scene 1. During a sequence of proactive braking interventions, the information sharing system displayed the visual content in accordance with the vehicle control in some experimental conditions. Fig. 9 shows the displayed visual contents in scene 1.

![Fig. 7 Overhead view of course 1](image)

![Fig. 8 Appearance of scene 1](image)

![Fig. 9 Displayed visual contents in scene 1](image)

Furthermore, in the latter half of the course, there is a curved area for a left turn. Hereafter, we refer to this area as scene 2. This scene reproduced the apparently dangerous scene where a vehicle might depart from the lane due to overspeeding. From
approximately 35 m before the entrance of the curve, the vehicle started to decelerate, and the velocity at the curve entrance is approximately 10 km/h. Fig. 10 shows the appearance of scene 2. Fig. 11 shows the displayed visual contents in scene 2.

Fig. 10  Appearance of entrance of scene 2

Fig. 11  Displayed visual contents in scene 2

3.4. Instructions for participants

Before the experiment, we gave the following instructions to the participants.

- The system that the participants experienced was not the autonomous driving system but the driving assistance system.
- In situations where visibility was not good due to occlusions, the vehicle might collide with a pedestrian rushing out from the occluded area. From approximately 35 m before the parked vehicle, the vehicle started to decelerate, and the velocity at the point beside the parked vehicle was approximately 10 km/h. Fig. 13 shows the appearance of scene 3, and Fig. 14 shows the displayed visual contents of scene 3.

Fig. 12  Overhead view of course 2

Fig. 13  Appearance of scene 3

Among the parameters of the prototype vehicle controls, the deceleration rate and the velocity at the end-point of the braking intervention, which determined the distance of deceleration, depended on the situations of the proactive braking intervention. Because the purpose of this study was not the parameter study but the discussion about the mechanism of the acceptance and refusal for the intervention system, we needed to set up the control parameters that clearly represented the characteristics of the proactive braking intervention. Thus, in this study, we made these parameters safer and earlier than the assumed practical ones in future actual situations. To be more precise, we set the deceleration rate as -1.0 m/s². The velocity at the end-point of proactive braking intervention in scene 1 was 5 km/h, and that in scenes 2 and 3 was 10 km/h.

3.5. Evaluation methods

The main purpose of this study was to confirm the total acceptance based on the discussions of the mechanisms of reactive acceptance and refusal, and those of comprehensive acceptance and refusal. First, to evaluate the reactive factors, we asked following questions.
A-1. “To what degree did you want to control an acceleration pedal by yourself instead of the system to cancel the intervention during braking intervention?”

A-2. “To what degree did you want to control a braking pedal by yourself instead of the system to control the deceleration during braking intervention?”

A-3. “To what degree did you feel that the system interfered with your driving during braking intervention?”

A-4. “To what degree did you feel anxiety during the braking intervention?”

Regarding questions A-1 and A-2, we considered the intention to control the pedals by oneself instead of by the system as the intention to correct the proactive braking intervention. Thus, if the participants agreed with these questions, we considered the intention to control the pedals by oneself instead of by the system as the refusal not for all of proactive braking intervention.

Regarding the comprehensive factors, we asked the following questions.

B-1. “To what degree did you feel that the system supports your driving?”

B-2. “To what degree did you feel that the system reduces the traffic accidents?”

Regarding the total acceptance, we asked the following question.

C-1. “To what degree did you want to introduce the system into your own vehicle?”

Participants selected the item from six grades to answer each question. The following shows the explanation of each grade.

Grade-1. The participant felt very much.
Grade-2. The participant felt so.
Grade-3. The participant felt a little.
Grade-4. The participant did not feel so much.
Grade-5. The participant did not feel.
Grade-6. The participant did not feel at all.

Because the focus of the evaluation was only the proactive braking intervention scene, we instructed the participants not to include the evaluations during the other states such as acceleration and cruising. In addition, we asked the abovementioned questions independently for all three scenes. Regarding the trials in which the HUD displayed visual contents, we asked only questions about reactive factors and total acceptance.

4. Analysis

4.1. Evaluations of the proactive braking intervention without information sharing system

4.1.1. Reactive factors

Fig. 15 shows the histogram of the evaluation results of the intention to control an acceleration pedal. Red, green, and blue bars represent the result of scenes 1, 2, and 3, respectively. Regarding the answer grade for the reactive factors, a smaller number indicates a more negative evaluation result. For example, we considered grade 1 for question A-1, i.e., “the participants very much felt the urge to control an acceleration pedal instead of the system”, as a strong refusal for an element of proactive braking intervention. As for the results of this question, although there were some positive evaluations, more than half were negative. Considering the mechanisms from the result of the free description questionnaires, early soft deceleration due to the proactive braking intervention had the possibility of making the participants feel impatience; additionally, it caused the partly negative evaluations.

![Fig. 15 Intention to control an acceleration pedal](image1)

Fig. 16 shows the evaluation results of the intention to control a brake pedal. In contrast to the results for the acceleration pedal, more than half were positive evaluations, although there were some negative evaluations. We considered the intention to control a brake pedal as the refusal not for all of proactive braking intervention, but for the implementations of partial elements such as the prototype control parameters of deceleration rate.

![Fig. 16 Intention to control a brake pedal](image2)

Fig. 17 shows evaluation results of feeling of interference and Fig. 18 shows the evaluation results of anxiety during the intervention. In both results, although there were some negative evaluations, more than half were positive. Comparing these results, the feeling of interference indicates a high number of negative evaluations rather than a feeling of anxiety.

![Fig. 17 Feeling of interference from the system](image3)

![Fig. 18 Feeling of anxiety during the intervention](image4)

4.1.2. Comprehensive factors

Fig. 19 shows the evaluation results of the feeling of being helped. Regarding the answer grade for the comprehensive factors, a smaller number indicates a more positive evaluation results. For example, grade 1 indicates that the participants very much felt the support of the system. As for the results of this question, they were positive.
Fig. 19 Feeling of being helped by the system

Fig. 20 shows the evaluation results of feeling the effect of a reduction in traffic accidents. Almost all the evaluations were positive. With respect to one evaluation, which was a grade 6, the participant might have missed the selection of the answer for the multiple-choice questionnaires because he wrote the positive opinion in the free description questionnaires.

Fig. 20 Feeling of effect for reducing traffic accidents

4.1.3. Total Acceptability

Fig. 21 shows the evaluation results of the desire to introduce the system into one’s vehicle. With respect to the answer grade for the total acceptability, a smaller number indicates a more positive evaluation result. Because almost all the evaluation results were positive, we confirmed that the participants basically accepted the examined system.

Fig. 21 Desire to introduce the system into one’s vehicle

4.1.4. Discussions

Table 1 summarizes the result of the abovementioned questions. From these results, we confirmed the following.

- The evaluations of the reactive factors contained partly negative ones.
- The evaluations of the comprehensive factors were positive.
- As a result, the participants accepted the examined system in total.

Furthermore, we thought that the distributions of the evaluation results of the feeling of interference and the evaluation results of the feeling of being helped supported the abovementioned findings. Although some participants responded that the system interfered their driving, no participants responded that the system did not support their driving. In summary, some participants considered the examined system as an interfering yet supportive system. This indicates the possibility that the mechanisms based on the comprehensive acceptance overwhelmed the mechanisms of the reactive refusal as discussed in section 2.2 and therefore this, furthermore, led the total acceptance.

Table 1 Summary of evaluations

| Genre | Topic | Evaluations |
|-------|-------|-------------|
| Reactive Factors | Intention to Control an Acceleration Pedal | Negative with some positive reactions |
| | Intention to Control a Brake Pedal | Positive with some negative reactions |
| | Feeling of Interference | Positive with some negative reactions |
| | Feeling of Anxiety | Positive with some negative reactions |
| Comprehensive Factors | Feeling of being Helped | Positive |
| | Feeling of Effect | Almost Positive |
| Total Acceptability | Desire to Introduce | Almost Positive |

It is also characteristic that the answer grades regarding the reactive factors exhibited a relatively wide distribution while the answer grades regarding the comprehensive factors exhibited a relatively narrow distribution. It is commonly pointed out that there are various characteristics of the elderly drivers. For example, some drivers want to drive the vehicle safely, and other drivers want to drive aggressively. From the perspective of the reactive factors, the former may accept the proactive braking, and the latter may refuse. Regarding the variety, it is commonly pointed out that the variety of the characteristics of elderly drivers is wider than that of younger drivers because of the driving experience over the ages. Thus, we thought that the wide distribution with respect to the reactive factors was caused by such varied characteristics. However, even such elderly drivers exhibited the concentrated distribution with respect to the comprehensive factors. On this point, we thought that a preliminary understanding of the system’s purpose and functionality, which were not discussed in our previous research, might be the reason for these concentrated results.

4.2. Evaluations of the proactive braking intervention with information sharing system

4.2.1. Reactive factors

Fig. 22 shows the comparison of the intention to control an acceleration pedal between in the conditions without and with the information sharing system. With respect to the reactive factors, a lower answer grade indicates a more negative evaluation result. Wilcoxon signed-rank test revealed a significant difference of the results at scene 1 under the 5% significance level. This result indicates the possibility that impatience of the drivers might be reduced by the gradual understanding of the intention of the proactive braking intervention owing to the information sharing system. On the contrary, regarding the results at scenes 2 and 3, because the participants could notice the apparently dangerous situations even without the information sharing system, there were not much effects due to the information sharing system; therefore, a significant difference was not confirmed. Although scene 3 had factors of the potentially dangerous situations as well as those of apparently dangerous situations, the similar effect at scene 1 was not confirmed at scene 3. This might be caused because factors of the apparently dangerous situations were visually more dominant than those of the potentially dangerous situations.
comparisons. Wilcoxon signed-rank test did not reveal any significant difference was not confirmed at scene 1. We thought that the reason was because of the ceiling effect, i.e., the evaluation results were relatively positive even without the information sharing system. Furthermore, this indicates that information sharing system did not reduce total acceptability under the 5% significance level.

4.2.3. Discussions
As discussed in the section 3.2, we needed to confirm the effect of the experimental order for the evaluation results. In this experiment, if the accustomization due to experimental order happened, the evaluation results regarding the reactive factors would be improved at scene 1 as well as scene 2 due to the uniformed arrangement of the experimental order. On this point, as Figs. 22, 23, and 24 show, although the significant differences were confirmed at scene 1, they were not confirmed at scene 2. Thus, although we could not fully deny the possibility of order effect, we thought that the effect of the experimental order was not dominant even if the order effect happened.

Based on the experimental results and the abovementioned discussions, we confirmed that the information sharing system had positive effects on the evaluation results regarding the following topic in the potentially dangerous scene 1.
• Intention to control an acceleration pedal
• Intention to control a brake pedal
• Feeling of interference from the system

In summary, we confirmed the possibility that the information sharing system might reduce the intention to modify the control of the system, and the feeling of impatience regarding the functionality of the system. We thought that providing the visual contents on the causes of potential dangerous situations and the plans of the proactive braking intervention might have compelled the participants to entrust the authority of the control to the proactive braking intervention system.

On the contrary, in the apparently dangerous scene 2, we confirmed that the information sharing system had positive effect for the evaluation regarding the feeling of anxiety. We thought that providing the visual contents regarding the apparent dangerous target, which the participants themselves considered as dangerous, might reduce the feeling of anxiety.

Regarding the total acceptability, we did not confirm any significant differences between conditions with and without HUD for all scenes. We thought that the reason is because of the ceiling effect, i.e., the evaluation results were relatively positive even without the information sharing system. Furthermore, this indicates that information sharing system did not reduce total acceptability under the 5% significance level.
5. Conclusions

To realize the proactive braking intervention system based on the advanced driver assistance system for elderly drivers, we evaluated the acceptability of a proactive braking intervention system and information sharing system through an experiment using an actual experimental vehicle on an actual test course. From the experimental results of 21 elderly drivers, we confirmed the following findings.

- Although the evaluations of the reactive factors included partly negative results, the evaluation results of the comprehensive factors and total acceptability were almost positive.
- Some participants considered the proactive braking intervention system as an interference to their driving from the viewpoint of reactive refusal, and simultaneously considered it as a driving support system from the viewpoint of comprehensive acceptance.
- The information sharing system could improve the evaluation results for some elements of the reactive factors without reducing the total acceptability in the potentially dangerous situations.

Although the abovementioned findings are useful to realize the proactive braking intervention system, further work is required toward the realization of this final goal. In this study, although the machine system controlled the velocity even in the acceleration situations for the reproducibility of the experiment, in the future, we will consider a braking intervention for the drivers' operation from the machine system. Thus, as the next step, we need to evaluate in more practical situations. In addition, as the system did not fail to control the vehicle at all in this study, evaluation of the overreliance under the conditions where the system sometimes fails is another future task. Considering these points, evaluations by a greater number of elderly drivers on actual public roads are the next step toward our final goal. In addition, although the discussions in this study were based on only the functional aspects, the cost is also important factor for the acceptance. Because the discussion of the cost depends on the degree of popularization, we cannot discuss the topic yet. Such discussion along with the popularization is also one of our future works.

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