A Study on the Effects of Intrinsic Motivation from Self-determination on Driving Skill

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Abstract. There are many novice drivers and inexperienced drivers who have difficulty driving a car. In this work, we focused on intrinsic motivation to increase the effectiveness of practice driving and support drivers' skill improvement. We proposed a system in which drivers themselves select what they pay attention to when driving from a list of options before driving. To verify the effectiveness of the proposed method, we compared a case in which the driver selected what to pay attention to when driving from among three options and a case in which the experimenter told the driver what to pay attention to when driving. The experiment results showed that intrinsic motivation was better than extrinsic motivation in preventing drivers from overcorrecting the steering wheel angle. However, there was no difference between the two in the skills of maintaining a constant speed and being aware of the left and right-hand width because of their difficulty to master.

Keywords: Driving, Intrinsic motivation, Self-determination, Driving skill improvement.

1 Introduction

There are many novice drivers and inexperienced drivers. It has been shown that inexperienced young drivers have poor risk perception and are more likely to cause accidents [1-5]. Many training programs have been conducted to improve the driving skills of inexperienced drivers [6-9], and there have been numerous experiments using simulators [10-13].

In this work, we first conducted a questionnaire survey on driving using Yahoo! Crowdsourcing for Japanese drivers with driver's licenses. Then, we received 2,609 responses (1519 males, 1056 females, and 34 others) after removing inauthentic responses. From this survey, we found that 40% of respondents drove a car daily, and 20% drove "less than once every few months" or "rarely." We also found that novice and inexperienced drivers were more likely than other drivers to feel that they were not good at driving (see Fig. 1). In addition, we asked about issues they had difficulty with when driving. Then we found that 29% of novice and 42% of inexperienced drivers

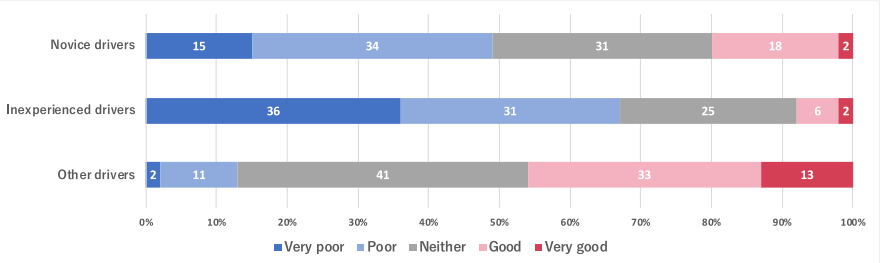

Fig. 1. Level of difficulty in driving a car (Q. Are you a good driver or a poor driver?).

indicated that they were poor at steering wheel operation. Furthermore, novice and inexperienced drivers were less skilled at changing direction and driving at high speeds compared to other drivers.

From these results, we can say that a system should be designed to improve the driving skills of those who are not good at driving while motivating them to drive and increasing the effectiveness of their driving practice.

Intrinsic and extrinsic motivations for doing something are well-known [14]. Intrinsic motivation is when there is no external reward, such as money, and the action itself is the goal. Extrinsic motivation is motivated by external stimuli such as money, reward, or coercion. Several studies have clarified that intrinsic motivation is more likely to lead to richer experiences, better problem-solving, and sustained effects [15]. Therefore, if we induce intrinsic motivation in novice or inexperienced drivers for driving practice, their driving skills might improve.

Ryan et al. [16] found that intrinsic motivation is promoted in situations where competitiveness, autonomy, and relatedness are met. Self-determination theory also reveals that autonomy influences motivation and that greater autonomy increases intrinsic motivation. In other words, self-determination plays an essential role in inducing intrinsic motivation. Deci et al. [17] found that the feeling of self-determination in choosing one's tasks enhances intrinsic motivation.

We hypothesize that intrinsically motivated drivers would focus more on driving skills and would improve their driving skills more than extrinsically motivated drivers. We also propose a method that enhances intrinsic motivation by making drivers choose a driving skill to focus on before driving. This method requires drivers to select a target driving skill from three driving skills and to drive while focusing on the selected skill. We also implement a system and verify our hypothesis through experiments using a driving simulator.

2 Experiment

This study aimed to improve driving skills through intrinsic motivation and hypothesized that "intrinsically motivated drivers will focus more on their driving and improve their driving skills more than extrinsically motivated drivers."

We conducted a comparative experiment to verify the proposed method's effectiveness. We divided the experimental participants into two conditions as follows.

- The participants themselves chose what they paid attention to when driving (intrinsic motivation condition).
- The experimenter told the participants what to focus on (extrinsic motivation condition).

2.1 Implementation of the Experimental System

For the experiment, we improved an experimental driving simulator [19], which enables the experimenter to set straight lengths, curved lengths, and curve radii. The experimenter could control the road width for each trial.

We also implemented a motivational system. For the intrinsic motivation condition, the system showed three buttons for choices on the screen (see Fig. 2). Once an option was selected, it could not be selected again. For the extrinsic motivation condition, one of the three options was randomly displayed on the screen (see Fig. 3).

The scene of the experiment is shown in Fig. 4. We used the Podium Lenkrad Classic 2 for the steering wheel, Club Sport Wheel Base V2.5 for the steering controller, Club Sport Pedals V3 Inverted for the pedals, Next Level Racing for the seat, the Oculus Quest 2 for the head-mounted display and an iPad for the motivational system.

2.2 Driving Skills Used in the Experiment

To induce intrinsic motivation to drive, participants in the intrinsic motivation condition were presented with a choice of basic driving skills and asked to select one skill that they would pay attention to in their subsequent driving. The participants in the extrinsic motivation condition were given instructions on the basic driving skills to pay attention to in the experiment.

The following instructions on driving skills were selected to be presented to the experimental participants: “Watch out for the left and right-hand width,” “Keep the speed constant,” and “Steer with as little steering angle correction as possible.” We chose these options because maintaining a constant speed and having a feel for the vehicle are essential for safe driving. Furthermore, driving with too much turning of the steering wheel decreases vehicle ride comfort and stability. In particular, novice and

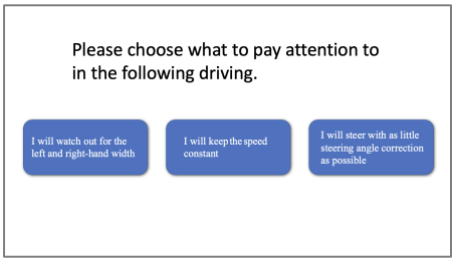

Fig. 2. Intrinsic motivation mode screen.

Fig. 3. Extrinsic motivation mode screen.

Fig. 4. Scene of the experiment.

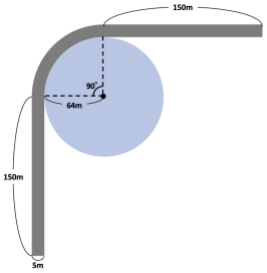

Fig. 5. Diagram of the course.

inexperienced drivers who are not accustomed to driving do not have a sense of the steering angle when driving around curves. They tend to correct the steering more frequently.

To check these driving skills, we set up a 400-meter-long course for the experiment, consisting of a straight line of 150 meters, a curve of 100 meters, and a straight line of 150 meters (Figure 5). The curve had a radius of 64 meters and an angle of 90 degrees, and the road width was five meters. Since it has been shown that there is no difference between left and right-turn curves [18], this experiment was limited to right-turn curves.

2.3 Experimental Procedure

The experimental procedure was as follows.

1) We asked the participants to practice driving the course until they were satisfied with it so they could familiarize themselves with the driving simulator. We instructed the participants to drive from 40 km/h to 60 km/h.
2) We presented the motivational system to the participants and asked them to use it. In the intrinsic motivation condition, we asked the participants to choose what they would be careful about when driving. In the extrinsic motivation condition, we asked the participants to read and confirm the driving instructions displayed on the motivational system.
3) We asked the participants to drive the course on the driving simulator ten times.
4) The participants took a five-minute break.
5) Process (2)-(4) was repeated three times.
6) We asked the participants to answer a post-experiment questionnaire (using a five-point Likert scale to indicate how much they were conscious of the skills selected or instructed in each set of driving motivation systems).

Each course began with a countdown. One course ended when the driver had driven to the end of the course. If an accident occurred due to contact with the guardrails, the driving ended there. At the end of the set, the trial that resulted in the error was presented again, and the measurement was retaken.

3 Results

The number of subjects was 14 university and graduate students (13 males and one female) between the ages of 18 and 25. They owned a driver's license and drove less than two to three times per month, and had experience with the simulator. There were seven subjects in both the intrinsic and extrinsic motivation conditions.

In this study, we prepared three options and analyzed each of the driving skills as follows:

- When "Watch out for the left and right-hand width" was selected or instructed, we analyzed it by the degree of deviation from the center of the road. Specifically, the starting point of the course was set as the center of the road, and the deviation from the center was calculated integrally from time to time.
- When "Keep the speed constant" was selected or instructed, we analyzed it by the standard deviation of the speed. Since the driver continues to accelerate until a constant speed is reached in the first 100 meters immediately after the start of the course, we set the calculation target for the standard deviation of speed from 100m to 400m (the end of the course).
- When "Steer with as little steering angle correction as possible" was selected or instructed, we analyzed it by finding the number of times the steering was corrected. To assess corrective steering, the number of times the steering wheel angle changed from positive to negative and from negative to positive while driving was counted.

Figures 6-8 compare intrinsic and extrinsic motivation in driving skills for each of the three options. The statistical evaluation showed no significant difference between intrinsic and extrinsic motivation in any of the skills. Here, feedback from the post-experiment questionnaire indicated that the participants felt that the vehicle body was shifted to the left. Therefore, it may be possible that the "Watch out for the left and right-hand width" instruction was not appropriate as an option due to the difficulty of finding the center of the road.

In addition, Fig. 7 compares the standard deviation of driving speed when "Keep the speed constant" was selected or indicated with intrinsic and extrinsic motivation. The results show no difference between intrinsic and extrinsic motivation for "Keep the speed constant."

On the other hand, Fig. 8 compares the number of times the driver corrected the steering wheel for intrinsic and extrinsic motivation when the option selected by the driver or shown by the experimenter was "Steer with as little steering angle correction as possible." The results show that the number of steering corrections tended to be fewer in the intrinsically motivated group than in the extrinsically motivated group.

In the post-experiment questionnaire, we asked the participants, "How conscious were you of the instructions selected or indicated in each set?" We asked participants to rate their level of consciousness on a five-point scale from 1 (not conscious at all) to 5 (very conscious) (see Fig. 9). The subjective evaluation showed that the extrinsic motivation group was more conscious of the skill in both the trial in which they were careful to keep a constant speed and the trial in which they were careful about how they turned the steering wheel.

4 Discussion

Fig. 7 shows no difference between intrinsic and extrinsic motivation in “Keep the speed constant.” On the other hand, Figure 8 indicates that the intrinsically motivated group tended to have fewer steering corrections than the extrinsically motivated group in the set in which they were careful to correct the turning of the steering wheel. In other words, motivation through making one’s own choices may be more effective for improving skill in steering corrections than when others give instructions.

For the participants in the experiment, “Steer with as little steering angle correction as possible” literally required the participant to focus only on the steering wheel, which was direct manipulation. On the other hand, “Keep the speed constant” was indirect; the participant controlled the speed by stepping on the accelerator pedal. We believe that intrinsic motivation by choosing what to pay attention to when driving may be effective for improving driving skills whose operation is direct and easy to understand. We prepared three options, “Watch out for the left and right-hand width,” “Keep the speed constant,” and “Steer with as little steering angle correction as possible” for this experiment. “Steer with as little steering angle correction as possible” was easy to understand from a sensory point of view since the focus was on steering adjustments. In addition, the driver only needed to be aware of direct steering wheel actions. On the other hand, the skill of keeping the speed constant required a complex combination of the steering wheel and acceleration operations. The complexity of the operations may

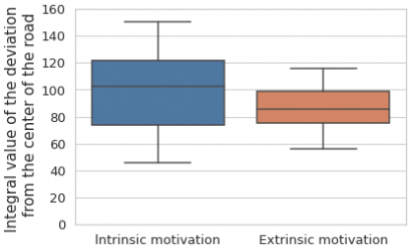

Fig. 6. Comparison of the integral value of the deviation from the center of the road when “Watch out for the left and right-hand width” was selected or instructed.

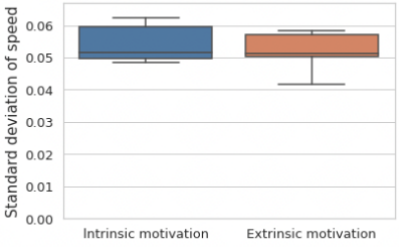

Fig. 7. Comparison of the standard deviation of speed when “Keep the speed constant” was selected or instructed.

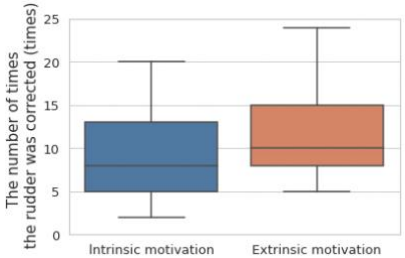

Fig. 8. Comparison of the number of steering corrections when “Steer with as little steering angle correction as possible” was selected or instructed.

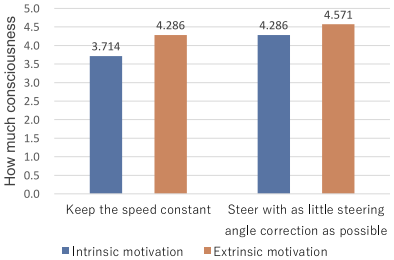

Fig. 9. Subjective evaluation.

have prevented the driver from developing motivation. The experimental results showed that intrinsic motivation was effective only for corrective steering, suggesting that intrinsic motivation is more likely to be effective in tasks where the operation is direct and easy to understand. Thus, there is a possibility that effective motivational styles for skill improvement will vary depending on the difficulty and proficiency of the skill, so further study is needed.

In the post-experiment questionnaire, several participants answered, “I felt the car body was shifted to the left” and “the steering wheel felt different from the actual car.” This feedback suggests that the results may have been affected by difficulty in finding the center of the road and the problem of keeping the center of the road in a curved section. It is also possible that some participants did not interpret the “Watch out for the left and right-hand width” task as keeping to the center of the road. Therefore, we should prepare much more appropriate tasks in the future.

In the subjective evaluation conducted after the experiment, the extrinsically motivated group was more conscious when the instruction was “Keep the speed constant” and “Steer with as little steering angle correction as possible.” On the other hand, the number of steering corrections was fewer in the intrinsically motivated group than in the extrinsically motivated group. This result suggests that extrinsic motivation may not be very effective in improving specific skills just because they are assumed to be conscious.

5 Conclusion

In this study, we proposed a method to support novice and inexperienced drivers by inducing intrinsic motivation to drive by letting the drivers choose the skills they would pay attention to in subsequent driving sessions immediately before driving. We experimented by comparing cases in which the drivers themselves chose what to focus on and cases in which the experimenter told them what to focus on to verify whether the driving skills they chose improved. The results showed that the number of corrective steering maneuvers carried out by directly manipulating the steering wheel was lower in the intrinsically motivated group than in the extrinsically motivated group. The results also suggest that intrinsic motivation may be more effective for improving direct manipulation skills than skills that require complex manipulation.

We first plan to reconsider the driving skills to be selected in the future. In addition, we plan to continue making improvements and seeking the actual driving skills required by users. On the other hand, the driving simulator differed from the actual car in some areas, such as the feel of the vehicle and braking, and we plan to further address these problems by improving the simulator.

References

1. McKnight, A. J., McKnight, A. S.: Young novice drivers: careless or clueless? Accident Analysis & Prevention 35(6), 921-925 (2003).

2. Machin, M. A., Sankey, K. S.: Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. Accident Analysis & Prevention 40(2), 541-547 (2008).
3. Deery, H. A.: Hazard and risk perception among young novice drivers. Journal of safety research 30(4), 225-236 (1999).
4. Vassallo, S., Smart, D., Sanson, A. Harrison, W., Harris, A., Cockfield, S., Mclntyre, A.: Risky driving among young Australian drivers: trends, precursors and correlates. Accident Analysis & Prevention 39(3), 444-458 (2007).
5. Pradhan, A. K., Hammel, K. R., DeRamus, R., Pollatsek, A., Noyce, D. A., Fisher, D. L.: Using eye movements to evaluate effects of driver age on risk perception in a driving simulator. Human factors 47(4), 840-852 (2005).
6. Isler, R. B., Starkey, N. J., Sheppard, P.: Effects of higher-order driving skill training on young, inexperienced drivers' on-road driving performance. Accident Analysis & Prevention 43(5), 1818-1827 (2011).
7. Fisher, D. L., Pollatsek, A. P., Pradhan, A.: Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? Injury Prevention 12, i25-i29 (2006).
8. Agrawal, R., Knodler, M., Fisher, D. L., Samuel, S.: Advanced virtual reality based training to improve young drivers' latent hazard anticipation ability. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting 61(1), pp. 1995-1999. SAGE Publications, Sage CA: Los Angeles (2017).
9. Regan, M. A., Deery, H. A., Triggs, T. J.: Training for attentional control in novice car drivers: A simulator study. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting 42(20), pp. 1452-1456. SAGE Publications, Sage CA: Los Angeles (1998).
10. Jamson, S. L., Hibberd, D. L., Jamson, A. H.: Drivers' ability to learn eco-driving skills; effects on fuel efficient and safe driving behaviour. Transportation Research Part C: Emerging Technologies 58(D), 657-668 (2015).
11. Fisher, D. L., Laurie, N. E., Glaser, R., Connerney, K., Pollatsek, A, Duffy, S. A., Brock, J.: Use of a fixed-base driving simulator to evaluate the effects of experience and PC-based risk awareness training on drivers' decisions. Human factors 44(2), 287-302 (2002).
12. Roenker, D. L., Cissell, G. M., Ball, K. K., Wadley, V. G., Edwards, J. D.: Speed-of-processing and driving simulator training result in improved driving performance. Human factors 45(2), 218-233 (2003).
13. Ivancic IV, K., Hesketh, B.: Learning from errors in a driving simulation: Effects on driving skill and self-confidence. Ergonomics 43(12), 1966-1984 (2000).
14. Ryan, R. M., Deci, E. L.: Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary educational psychology 25(1), 54-67 (2000).
15. Deci, E. L., Flaste, R.: Why we do what we do: The dynamics of personal autonomy. GP Putnam's Sons (1995).
16. Ryan, R. M., Deci, E. L.: Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American psychologist 55(1), 68-78 (2000).
17. Zuckerman, M., Porac, J., Lathin, D., Deci, E. L.: On the importance of self-determination for intrinsically-motivated behavior. Personality and social psychology bulletin 4(3), 443-446 (1978).
18. Funazaki, Y., Seto, N., Ninomiya, K., Hikawa, K., Nakamura, S., Yamanaka, S.: Driving Experiment System Using HMDs to Measure Drivers' Proficiency and Difficulty of Various Road Conditions. In: Krömker, H. (eds.) HCI in Mobility, Transport, and Automotive Systems, HCII 2022, LNCS, vol. 13335, pp. 247-257. Springer, Virtual Event (2022).