Education Method for Safe Bicycle Riding to Evaluate Actual Cycling Behaviors When Entering an Intersection

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Abstract. In this study, we conducted a new educational method for safe bicycle riding to improve the riding manners of bicyclists riding manners to increase adherence to traffic rules. First, we conducted an experiment in which participants rode a bicycle and passed through an intersection to collect such data as bicycle speed and the rider's direction of glance. Next, we did a simulation in which a bicycle passed through an intersection to evaluate riding behaviors. Finally, an experimenter explained to the participants how they could improve their safe bicycle riding awareness using the data collected in the experiment and the simulation results. The participants learned that safety can be confirmed by looking right and left to decrease the risks of accidents.

Keywords: Educational method · Safe bicycle riding · Cycling behavior · Crossing collision

1 Introduction

Bicycles are a convenient vehicles, especially because bicyclists do not need a license. Such convenience and simplicity may increase a bicyclist's lack of safe bicycle riding habits. The numbers of crossing collisions between bicycles and pedestrians at intersections in Japan are increasing [1]. The dangerous riding behavior of bicyclists is a social problem in Japan. Crossing collisions account for around 50 % of all bicycle accidents [1]. Takemoto proposed a new educational method for car drivers using a driver model based on the analysis of driver behaviors when passing through intersections and a simulation that evaluated driving behaviors [2]. We tentatively applied the teaching methods proposed in the previous study [2] to a new method for bicyclists to improve their riding behaviors [5]. We also found that our teaching method was effective to raise safe bicycle riding awareness [5]. In this paper, we report our experiments with a new educational method for safe bicycle riding.

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2 Experiment

2.1 Participants and Experimental Course

We conducted experiments to collect data while the participants passed an intersection. The participants in this study were nine college students 19–20 years old who volunteered for this experiment. Four of the nine participants passed through the intersection when they went to school and the remaining participant passed through the intersection around three times a week or few times a year. Figure 1 shows an intersection selected for collecting data in the experiment. We defined that the position where a participant just entered the intersection was zero and that the position of a participant before entering the intersection was minus and the position after entering the intersection was plus.

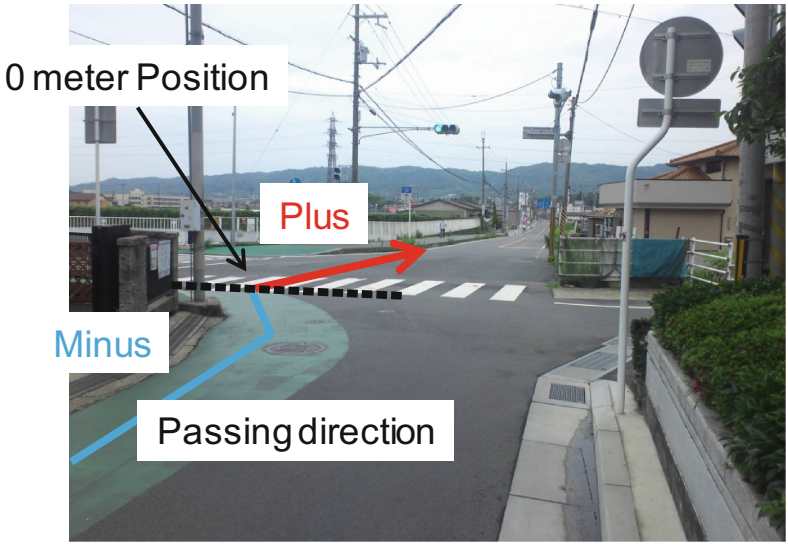


Fig. 1. Intersection for experiment

2.2 Apparatus

The experimenter used an Eye Mark Recorder EMR-9 (NAC) to record an image of the front view of the rider and the direction of glance. A laser displacement meter LD90-3300 (RIEGL) was used to record speed of the bicycle while passing through the intersection.

2.3 Procedure

The participants rode the bicycle and passed through the intersection shown in Fig. 1. We collected the speed of the bicycle and the participant's direction of glance while

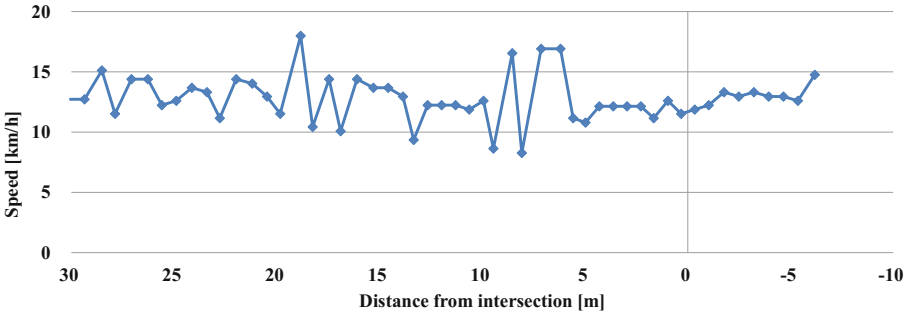
passing through the intersection. The traffic light turned green and no objects such as cars, bicycles or pedestrians obstructed the passing of the participants through the intersection. The experimenter recorded the participant's speed and direction of glance when passing through the intersection.

3 Experimental Results

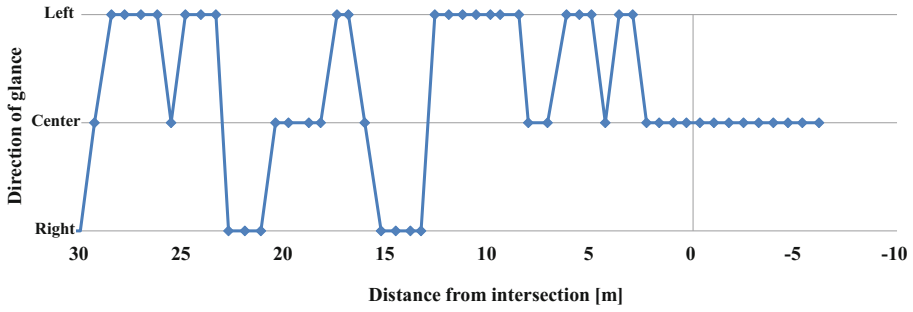
We discuss the experiment results of eight participants because we failed to collect the data of one participant during the experiment.

Figure 2 shows the bicycle speed and the direction of glance while participant A passed through the intersection. Figure 2(a) shows that he rode at a speed almost between 10 and 15 km/h before entering the intersection. Figure 2(b) shows that he glanced left six times before entering it.

We calculated the average speed and the number of confirmations made by looking left for each participant to analyze the collected data. Figure 3 shows the average speed and the number of confirmations of each participant. The participants confirmed by looking left fewer times while passing through the intersection because they passed at a faster speed.



(a) Speed



(b) Direction of glance

Fig. 2. Speed of bicycle and direction of glance while participant A passed through intersection

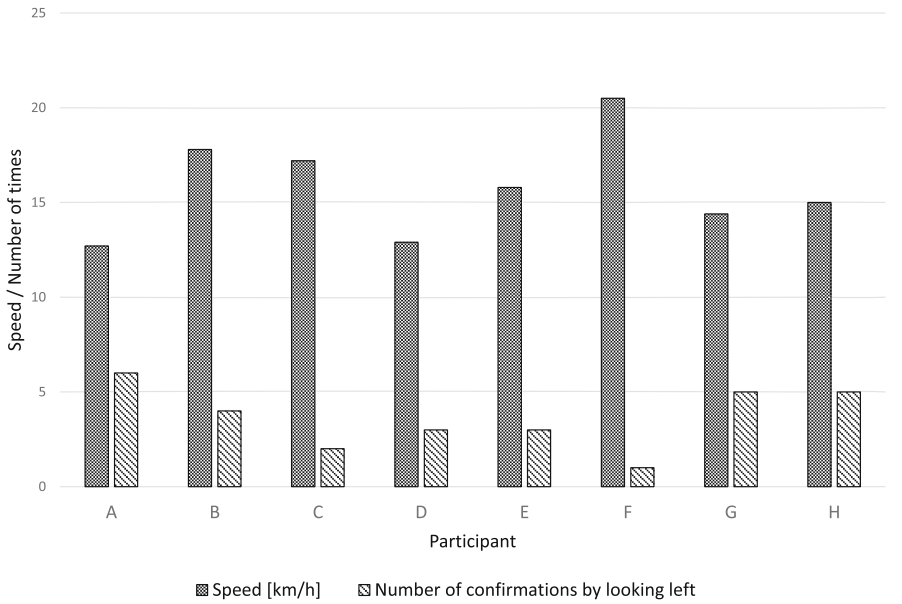


Fig. 3. Average speed and number of confirmations by looking left while participant passed through intersection.

4 Evaluation of Safe Bicycle Riding Behavior When Passing Through an Intersection

4.1 Simulation of Passing Through an Intersection

We simulated a bicycle ridden by a participant who is passing through an intersection in the presence of a crossing bicycle to evaluate her/his safe bicycle riding behavior. We conducted a simulation that visualized the risk to a bicycle rider in various potentially hazardous situations by changing the speed and initial positions when she/he passed through an intersection. The input data of the program are the bicycle speed, the direction of the participant's glance, and the degree of the participant's view on the left side at each of the participant's positions while passing through the intersection. The output of the program is whether accidents between the bicycle ridden by the participant and the crossing bicycle were caused. The number of combinations of the initial position and speed of the crossing bicycle was 12. We simulated 12 combinations for each participant and counted the number of accidents between crossing bicycles and the bicycles ridden by each participant.

Table 1 shows the simulation results. Participants A, D, E, G, and H caused no accidents, and participants B, C, and F caused accident twice, three times and five times during the 12 simulations respectively. We assume that participants B, C, and F have more bicycle riding behavior should be improved than participants A, D, E, G, and H.

Table 1. Accident rate

Participant	A	B	C	D	E	F	G	H
Accident rate [%]	0	17	25	0	0	42	0	0

4.2 Relation Between Bicycle Speed and Number of Confirmations by Looking Left and Accident Rate

Figure 4 shows the relation between bicycle speed and number of confirmations by looking left. The average speed of the participants who caused accidents in the simulation exceeded the speed of the participants who never caused accidents. This figure also suggests that the average bicycle speed was faster, and the number of confirmations by looking left was fewer. We assume that this is because participants must decrease the bicycle speed to make enough confirmations by looking left when passing through an intersection.

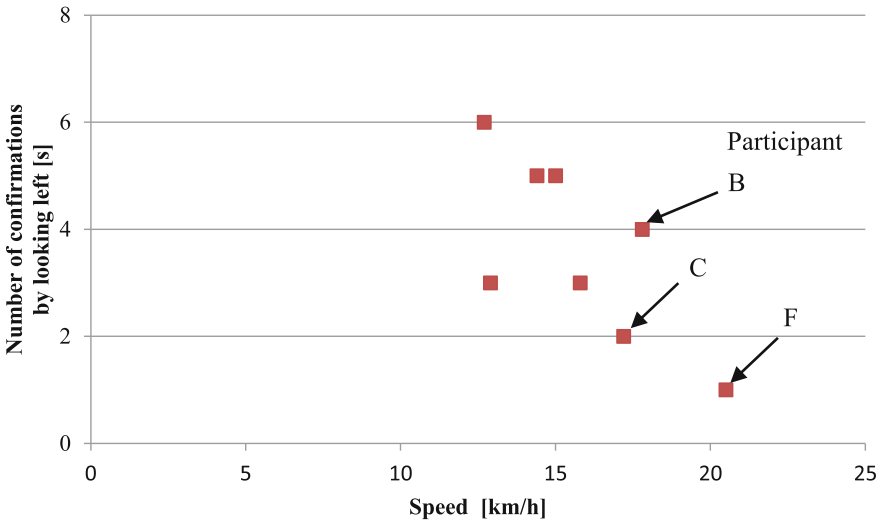


Fig. 4. Relation between bicycle speed and number of confirmations by looking left

5 Safe Bicycle Riding Education

5.1 Education Procedure

We educated the participants to improve their bicycle riding behavior and raise their awareness. Figure 5 shows our education procedure.

First, the experimenter questioned the participants about such items as knowledge of traffic rules for riding a bicycle. Next, the participants watched a video of their eye movements and front view while they passed through the intersection. They also saw

graphs of bicycle speed and the direction of glance. The experimenter showed them their own simulation images and results. The experimenter also showed participants B, C, and F the results of the simulation in the case where they improved their bicycle riding behaviors. The experimenter explained that improving confirmations of safety by looking left decreased the risk of accidents to all the participants. Finally, participants drove on a driving simulator and encountered at a blind spot that a bicycle suddenly crossed the path of their car. After this, the experimenter explained to them that this was a case where it is difficult for drivers to see a bicycle while driving, and the driver caused an accident.

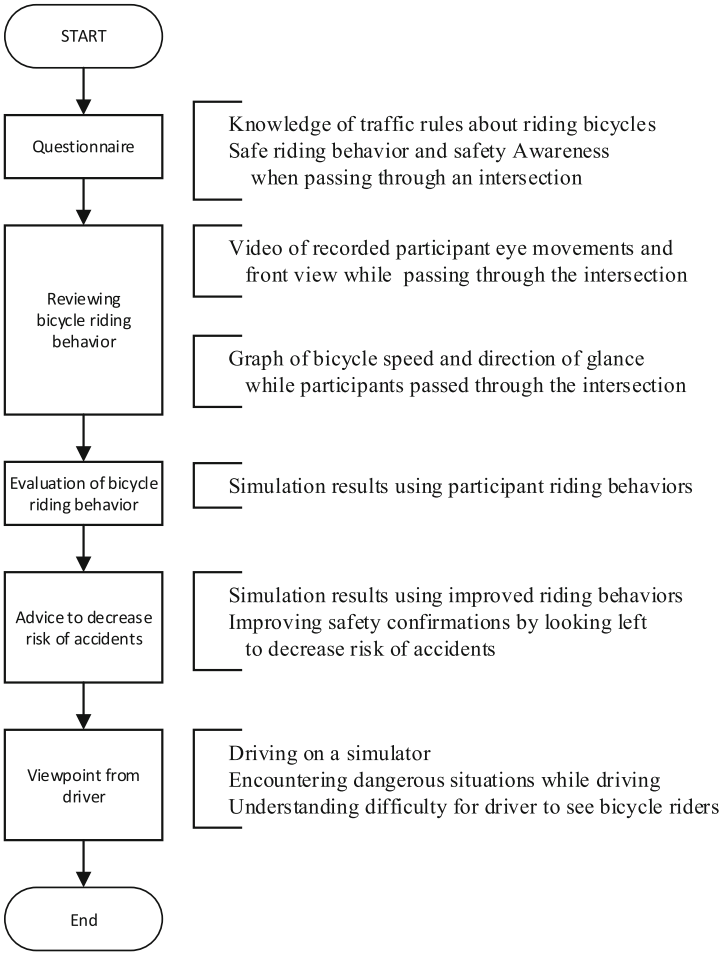


Fig. 5. Education procedure

5.2 Results

We conducted a questionnaire about the knowledge of traffic rules held by our participants about riding a bicycle, safe riding behaviors, and their awareness of safety when passing through an intersection. Table 2 shows the answers to one of the questionnaire questions: "How do you look left and right to confirm safety when entering an intersection?" An appropriate answer is: "I confirm safety by looking right and left many times when entering an intersection to see the far end of an intersection to avoid crashing into a crossing object at the intersection." No participants gave the appropriate answer. Participants C and F, who caused accidents in the simulation in Sect. 4.1, answered that they confirmed safety by sufficiently looking left and right when entering an intersection to prevent accidents. On the other hand, participants C and F glanced left only once or twice before entering the intersection based on their experimental results and their riding behaviors when entering the intersection were inadequate to prevent accidents.

After such education, all participants answered that they did not know that improving their safety confirmations by looking right and left decreases the risk of accidents, but they understood this after studying the simulation results using their own riding behavior data.

Table 2. Answers: how do you look left and right to confirm safety when entering an intersection?

Participant	Answer
A	No answer
B	I decide based on the situation and circumstances.
C	My own way of confirming safety by looking left and right when entering an intersection is enough to prevent accidents.
D	I am not sure.
E	I am not sure.
F	My own way of confirming safety by looking left and right when entering an intersection is enough to prevent accidents.
G	It is enough that I confirm safety by looking left, right, and left when entering an intersection.
H	I decide based on the situation and circumstances.
I	I am not sure.

6 Conclusion

In this study, we conducted experiments that focused on an educational method for safe bicycle riding. First, we experimentally collected participant riding behaviors while passing through an intersection. We evaluated their safe riding behaviors using the collected riding behavior data and the simulation data of bicycles ridden by participants who were passing through an intersection in the presence of a crossing bicycle under various conditions. Our evaluation results suggest that bicycle riders have to decrease their bicycle speed to confirm the safety by looking right and left and that riders have made enough confirmations by looking right and left only after they decrease bicycle speed when passing through an intersection.

Finally, we conducted safe bicycle riding education to raise the participants' bicycle riding awareness. The participants learned that safety can be confirmed by decreasing bicycle speed and looking right and left to decrease the risk of accidents.

Future research will verify the effectiveness of our education method.

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