Pilot Experiments in Education for Safe Bicycle Riding to Evaluate Actual Cycling Behaviors When Entering an Intersection

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Abstract. Previous studies have proposed educational methods to improve the basic driving behaviors of unsafe drivers by evaluating their actual driving behaviors. In this paper, we report on applying the teaching methods proposed by previous studies to a new method for bicyclists to improve their safe riding behavior and awareness. The results of our education experiments indicated that it was important for a rider to increase the chance of noticing a crossing bicycle by confirming safety by looking right and left. The participants did not have this knowledge before the education. After the bicycle riding simulation and education, they understood it was effective to confirm safety by looking right and left to decrease the risk of an accident.

Keywords: educational method, safe bicycle riding, cycling behavior, driving simulator.

1 Introduction

The number of traffic accidents in Japan has decreased recently, while the number of bicycle accidents has not. Typical bicycle accidents include crossing collisions between bicycles, between a bicycle and a car, or between a bicycle and a pedestrian at intersections in Japan [1]. Crossing collisions account for 50 percent of all bicycle accidents [1]. There are no riding assistance systems to prevent accidents, and an effective educational method for safe bicycle riding is required. Takemoto proposed a new educational method for car drivers using a driver model based on analysis of the driver's behavior when passing through an intersection and a simulation evaluating the driving behaviors [2]. We applied the teaching methods proposed by the previous study [2] to a new method for bicyclists to improve their riding behavior. In this paper, we report the pilot experiments in the new educational method for safe bicycle riding we conducted.

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2 Educational Method for Safe Bicycle Riding

Figure 1 shows an outline of the educational method for safe bicycle riding in this study.

First, an experiment in which a participant rides a bicycle and passes through an intersection is conducted to collect data such as bicycle speed and the rider's direction of glance while passing through the intersection.

Next, the collected bicycle speed and direction of glance in each bicycle position at the intersection are graphed. The participant can understand profiles of bicycle speed and direction of glance when he/she passes through the intersection by looking at these graphs.

A simulation in which a bicycle passes through the intersection is executed. Input data of the simulation is width of a rider's view at the intersection, bicycle speed and direction of glance collected in the experiment and map information of the intersection the participant passed through. In the simulation, a participant riding a bicycle passes through the intersection. The simulation has a crossing bicycle. The crossing bicycle has various conditions, initial positions of the bicycle and speeds while passing through the intersection. The simulation judges whether the bicycle ridden by the participant crashes into the crossing object at the intersection in each condition.

3 Experiment

3.1 Participants and Experimental Course

The participants in this study were six male college students 19-20 years old who volunteered for this experiment. All traveled to school by bicycle. Figure 2 shows an intersection selected for collecting data in the experiment. Five of the six participants passed through the intersection when they went to school and the remaining participant passed through the intersection once a week.

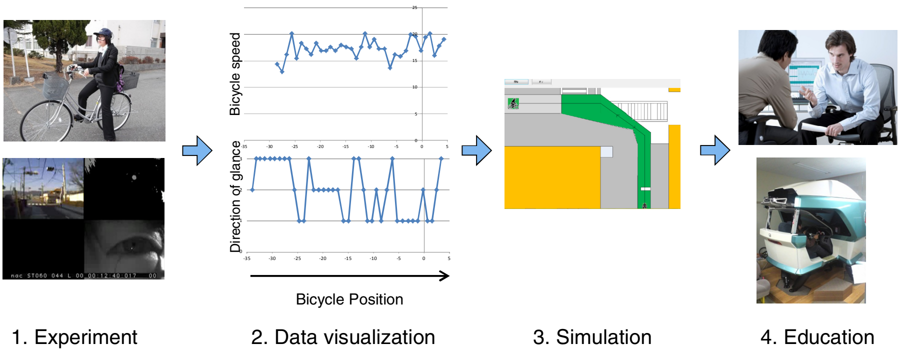


Fig. 1. Outline of educational method for safe bicycle riding

3.2 Apparatus

Figure 3 (a) shows the bicycle used for this experiment. 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. Figure 3 (b) shows an example image recorded by EMR-9. A laser displacement meter LD90-3300 (RIEGL) was used to record speed of the bicycle while passing through the intersection.

3.3 Procedure

The participants rode the bicycle and passed through the intersection shown in Figure 2. We collected the speed of the bicycle and the participant's direction of glance while

Fig. 2. Selected intersection for experiment

(a) (b)

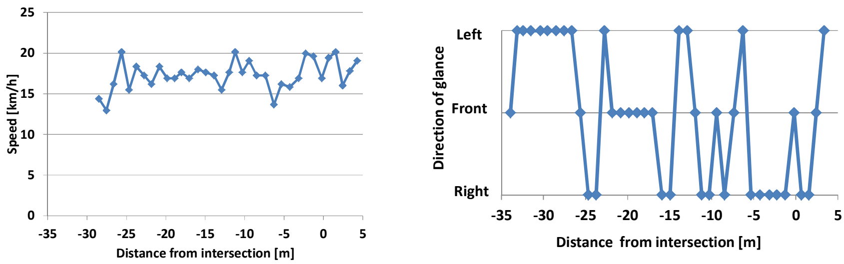
Fig. 3. (a) Bicycle for experiment and eye mark recorder (b) Image example recorded by eye mark recorder in experiment

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.

3.4 Results

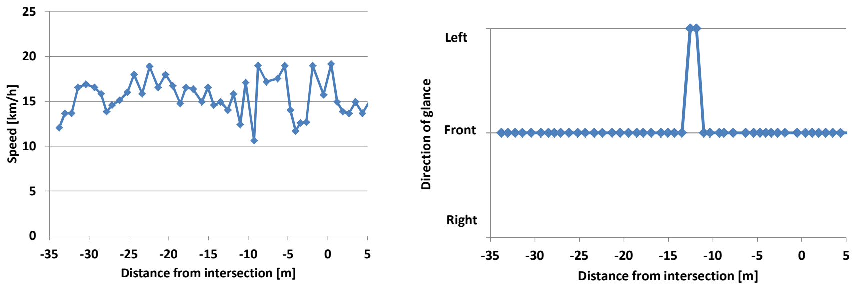
Figure 4 shows bicycle speed and direction of glance while participant D passed through the intersection. Figure 4 (a) shows that he rode the bicycle at a speed between 15 and 20 km/h before entering the intersection. This figure also shows that speed measurement error is large. The experimenter set his sights on the bicycle using the sighting device when the participant passed through the intersection. The setting of sights is difficult, and this was the main cause of measurement error. Figure 4 (b) shows that the participant glanced left four times before entering the intersection.

Figure 5 shows bicycle speed and direction of glance while participant E passed through the intersection. Figure 5 (a) indicates that he rode the bicycle at a speed of between 10 and 20 km/h before entering the intersection. Figure 5 (b) indicates that the participant glanced left only once before entering the intersection.



(a) Speed of bicycle (b) Direction of glance

Fig. 4. Speed of bicycle and direction of glance while participant D passed through intersection



(a) Speed of bicycle (b) Direction of glance

Fig. 5. Speed of bicycle and direction of glance while participant E passed through intersection

Table 1. Average speed, number of times used to confirm by looking left and time used to confirm by looking left while participant passed through intersection

Participant	Average speed [km/h]	Number of times used to confirm by looking left	Time used to confirm by looking left [s]
A	18.2	1	1.2
B	20.5	4	2.4
C	17.3	2	1.0
D	17.5	5	2.6
E	15.0	1	0.4
F	19.6	1	0.4

Table 1 shows average speed, number of times used to confirm by looking left and time used to confirm by looking left while the participant passed through the intersection.

4 Simulation to Pass through Intersection

We created a simulation program to visualize the risk of a bicycle rider in various potentially hazardous situations by changing the speed and initial position when the rider passed an intersection. We simulated a bicycle ridden by a participant passing through an intersection in the presence of a crossing bicycle.

Figure 6 shows a displayed image of the program. Input data of the program is bicycle speed, the direction of the glance of the participant as shown in Figure 4, and the degree of the participant's view on the left side at each of the participant's positions while passing through the intersection. We assumed that initial position of the crossing bicycle was 10 m, 15 m and 20 m from position X in Figure 6. We also assumed that the speed of the crossing bicycle was the same as the average speed of a bicycle ridden by a participant, 4 km/h faster than the average speed, 8 km/h faster than the average speed and 12 km/h faster than the average speed. The number of combinations of the initial position and speed of the crossing bicycle was 12. We simulated the 12 combinations for each participant, and counted the number of accidents between the crossing bicycle and the bicycle ridden by each participant in the simulation.

Table 2 shows the simulation results. Participants A and D caused no accidents. Table 1 shows that they confirmed safety by looking left relatively longer while passing through the intersection. Table 1 also shows that Participant B confirmed safety by looking left relatively longer and more times, but he caused an accident once. We assume that this is because the average speed of Participant B was 20.5 km/h, the fastest of all the participants. These results indicate that it is important for a rider to increase the chance to find a crossing bicycle by confirming safety by looking right and left, and to reduce the speed of the bicycle while passing through an intersection to prevent intersection accidents.

Based on the above, the main targets of our education on safe bicycle riding were participants B, C, E and F, who caused accidents in the simulation. We made it our main educational policy to help participants C, E and F understand that improving confirmation of safety by looking left will decrease the risk of accidents. We also made it our policy to help Participant B understand that reducing the speed of the bicycle is necessary to decrease the risk of accidents.

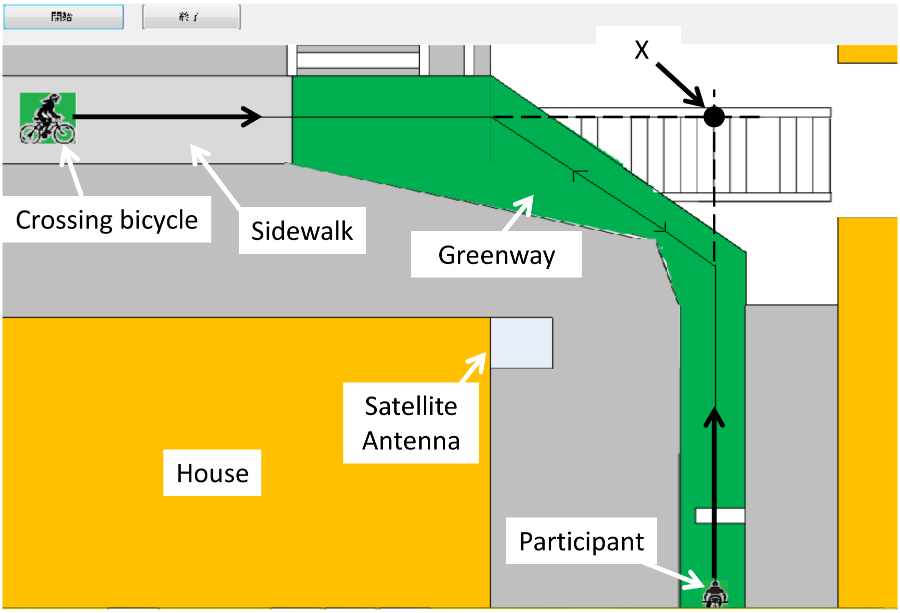


Fig. 6. Displayed image of simulation program

Table 2. Number of accidents in simulation

Participant	The number of accidents
A	0
B	1
C	4
D	0
E	5
F	6

5 Trial Safe Bicycle Riding Education

5.1 Procedure

We tried to educate the participant to improve his safe bicycle riding awareness. The following education procedure was conducted for the participant.

1. The experimenter questioned the participant about the following items:
   - Knowledge of traffic rules about riding a bicycle.
   - Safe riding behavior and awareness when passing through an intersection.
   - Safe riding behavior and awareness when passing through the intersection where the experiment was conducted.
2. The participant watched the following video images:
   - one in which the experimenter recorded the participant's eye movements and the front view while he passed through the intersection,
   - one of the intersection when the participant passed through it.
3. The experimenter showed the graph of bicycle speed and the direction of glance such as Figure 4 while the participant passed through the intersection.
4. The experimenter showed the participant the simulation images and results in his case. We showed participants B, C, E and F the following two cases of simulation results.
   - A case where the participant caused no accidents when entering the intersection. Speed of the crossing bicycle was same as the average speed of the bicycle ridden by the participant.
   - A case where the participant caused an accident when entering the intersection.
5. The experimenter explained the difference between the two cases and the reason the participant caused the accident. We also explained that improving confirmation of safety by looking left decreased the risk of accidents.
6. The participant drove a car on the driving simulator and encountered a bicycle at a blind spot that suddenly crossed the path of the car driven by him. After this, the experimenter explained to the participant that there was a case where it is difficult for a driver to see a bicycle while driving, and the driver caused an accident.

5.2 Results

All the participants answered that it is effective to reduce speed to prevent an accident between bicycles at an intersection, and that improving confirmation of safety by looking right and left is not effective in the questionnaire in 5.1. The simulation results showed that improving confirmation of safety by looking left decreases the risk of accidents. These results indicated that the knowledge that improving confirmation of safety by looking right and left is effective for decreasing the risk of accidents is new and important information for the participants.

All the participants also answered that they caused no accidents or could avoid an accident between bicycles at the intersection where the experiment was conducted in their usual riding behavior. Participants B, C, E and F subsequently understood that they might cause an accident between bicycles at the intersection under some conditions from the simulation results.

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

In procedure 6 in 5.1, all of the participants who drove a car on the driving simulator could not find the bicycle and caused an accident. The participants understood that car drivers cannot always see bicycles nearby and cause an accident. This knowledge is new for the participants who have never driven a car before. We expect that their understanding of this fact will motivate them to improve their confirmation of safety by looking right and left voluntarily.

6 Conclusion

In this study, we conducted pilot experiments in a new educational method for safe bicycle riding. First, we conducted an experiment to collect the participants' riding behavior while passing through an intersection. Second, we simulated the participants passing through the intersection in the presence of a crossing bicycle under various conditions. The results indicated that it was important for a rider to increase the chance to detect a crossing bicycle by confirming safety especially by looking right and left. Finally, we conducted safe bicycle riding education to improve the participants' safe bicycle riding awareness. The participants came to understand that it is effective to confirm safety by looking right and left to decrease the risk of an accident.

Future research will improve the educational method. We will also increase the number of participants and verify the effectiveness of our education method.

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