<V. Lightning Talk> Sign Planning for Pedestrians and Autonomous Vehicles : Design for a Next-Generation Road Environment

Lightning Talk

Sign Planning for Pedestrians and Autonomous Vehicles: Design for a Next-Generation Road Environment

MAEDA Moe,[1] YAMAMOTO Sari,[2] ITOH Makoto,[3] CHEN Zhangyijing [4]
[1] Master's Program in Art and Design, University of Tsukuba
[2] Faculty of Art and Design, University of Tsukuba
[3] Faculty of Engineering, Information and Systems, University of Tsukuba
[4] Doctoral Program in Risk and Resilience Engineering, Graduate School of Systems and Information Engineering, University of Tsukuba

ABSTRACT

While there have been a remarkable number of trials of autonomous vehicles in recent years, a suitable road environment for them has not yet been developed. This study was therefore conducted with the aim of creating an environment in which pedestrians and autonomous vehicles can communicate with each other and use roads safely. We conducted an experiment using 11 signs to determine which ones were easy for pedestrians to understand. A total of 60 subjects in each age group evaluated each sign, and we observed the actions of the subjects with respect to each sign making use of virtual vehicles in the "LargeSpace" virtual reality system. The results showed that signs indicating both pedestrian and vehicle behavior were the easiest to understand and least likely to be misunderstood.

1. INTRODUCTION

These days, roadway environmental design using colored pavement is on the rise across Japan to promote a reduction in traffic accidents (Hashimoto et al., 2015). On the other hand, a road system called Shared Space, which gives all road users a sense of "sharing the road," is starting to be used in sightseeing and residential areas (Nakagawa et al., 2017). Yamamoto, Nishikawa, et al. are investigating the methods and conditions of Shared Space in Europe and the United States, and are considering its full-scale introduction in Japan (Nishikawa et al., 2011; Yamamoto et al., 2011). Ozaki et al. found that the pavement design that was most effective in inhibiting vehicle speed was an oblique grid pattern (Ozaki et al., 2017).

It is hoped that easing vehicle congestion and preventing accidents will be possible as the technology related to autonomous driving improves. However, if the era of unmanned autonomous vehicles on public roads arrives, there could be situations in which pedestrians are stranded on a roadside or in the middle of a road, unable to make eye contact, as there is no driver in the vehicle. Toward solving this problem, we created a sign that indicates the intention of an autonomous vehicle as it approaches. The aim of having these presented on the road is to facilitate communicate between pedestrians and vehicles. The purpose of this study is thus to propose a next-generation road environment design. We will produce a road environment design that takes into account future technological developments in autonomous driving so that road users can use roadways safely.

2. METHOD

For this study, we conducted an experiment using the virtual reality (VR) system "LargeSpace" which Iwata et al. developed at the University of Tsukuba (Takatori et al., 2016). “LargeSpace” is a 15 × 25 × 7.7-meter all-round display with dedicated projectors and motion capture sensors. These projectors are used to show the road environment and a moving virtual vehicle on the displays. Also, we produced 11 road signs projected from another projector to the floor and conducted an experiment to ascertain which signs are easy for pedestrians to understand. The 11 signs are linked to the actions of autonomous vehicles, and each is associated with either “Pedestrian Stop: Vehicle Passing” or “Pedestrian Crossing: Vehicle Stopping.” Sixty Japanese subjects, 10 men and 10 women in each of three age groups (20s, 45–55, and 65–75 years old), were recruited to participate. The experiment was conducted from Jan. 23, 2020, to Mar. 22, 2020.

2.1 Sample Preparation

First, we created two signs, A and I, to use as a reference. Sign A means “Pedestrian Stop: Vehicle Passing,” and sign I means “Pedestrian Crossing: Vehicle Stopping” (Table 1: red frame). A total of 14 road signs were produced, varying the shape and color of Sign A and Sign I. Eleven road signs were used in the experiment, excluding those that were not expected to be effective (Table 1).

Table 1. List of road signs.

Sign	Angle	Color	Movement	CAV* mark	"Pedestrian Crossing" mark	"Pedestrian Stop" mark	Sign meaning
A	Acute angle	Red	Move	Not included		Arrow sign	Pedestrian Stop
B	Obtuse angle						Pedestrian Stop
C		Yellow					Pedestrian Stop
D		Green					Pedestrian Stop
F			Still				Pedestrian Stop
H				Included			Pedestrian Stop
L						Footprint	Pedestrian Stop
N						Sign A + L	Pedestrian Stop
I					Car stop		Pedestrian Crossing
J					Footprint		Pedestrian Crossing
M					Sing I + J		Pedestrian Crossing

* Connected Autonomous Vehicle

2.2 Experimental Procedure

(1) After explaining the experiment, the participants were asked to fill in certain attributes (gender, age and usual mode of transportation) and their impressions of each sign. (2) We then moved on to the main experiment. At the experimenter’s cue, a virtual vehicle and a random sign were shown to the participants. (3) Subjects were asked to judge whether the road sign is “Pedestrian Stop: Vehicle Passing” or “Pedestrian Crossing: Vehicle Stopping,” and to act accordingly. (4) The experimenter then made the following three observations: 1. whether the subject crossed the street without waiting for a car; 2. how long it took for the road sign to start moving after it was posted; and 3. where the subject was looking and how often. (5) After posting all the road signs to the subjects, a sign meaning “Pedestrian Crossing: Vehicle Stopping” was posted. However, the vehicle caused an accident when it passed. Following this, 11 road signs were posted again, one at a time at random. We then checked to see if the action was slower than before the accident. (6) Finally, the participants were asked to complete a survey.

3. RESULTS AND DISCUSSION

The results of the experiment showed that the movement began within 2.0–3.0 seconds for all genders and ages (Figure 1*). However, the time it took to start moving was faster after the accident. In other words, the effect of experimental procedure (5) was not obtained. For Sign J only, men aged 65–75 years showed a significant trend, with $p < .059$. Participants in their 20s and 65–75 years old were more likely to act immediately after the signs were presented. On the other hand, the subjects aged 45–55 years tended to wait for a while before they acted. Also, women tended to take longer to act than men. The graph shows that more than 70–80% of the people correctly understood the meaning of signs (Figure 2*). Also, based on answers to the questionnaire at the end of the experiment, Sign M was rated as the most obvious sign (Figure 3). (* The graph shows only the results before the accident.)

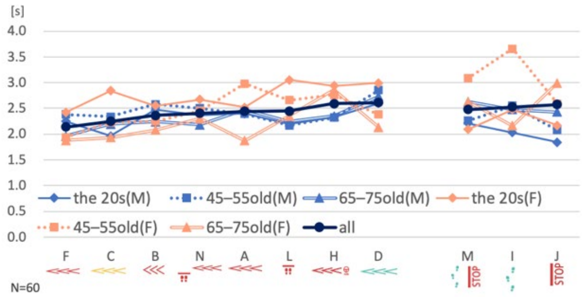

Figure 1. Average time between sign presentation and subject's movement.

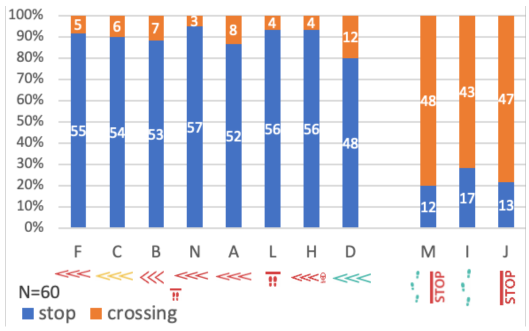

Figure 2. Subject's move after the presentation of a sign and until the vehicle passes by.

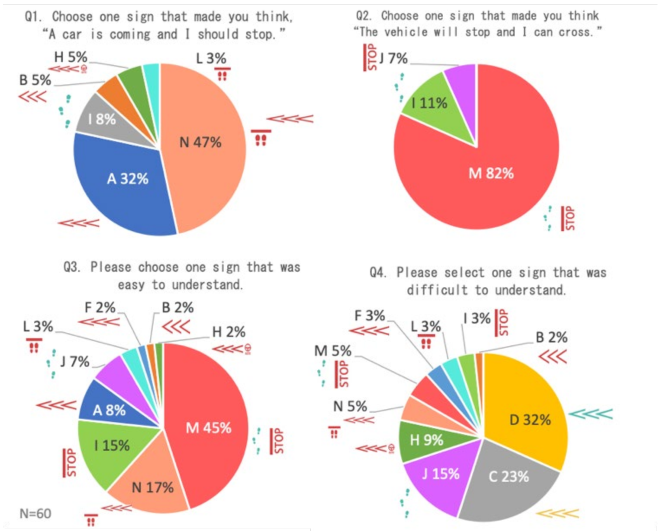

Figure 3. Survey results: Easy-to-understand signs and confusing signs.

It is likely that the subjects learned during the experiment and guessed the meaning of the signs and as a result accelerated the speed of their actions. However, Sign D had an overall slower rate of action, and this may be due to the subjects possibly considering whether to cross. Meanwhile, despite Sign M being chosen as a "most obvious sign," the subjects' rate of action was not fast. This may be because the sign is made up of two figures, and thus it takes time to understand their meaning. We also speculate that the speed at which subjects can move and the speed at which they can make decisions differ with age, leading to some differences in results. Since signs N and M are shown for vehicle and pedestrian, we can assume that the subjects had an easier time deciding on their actions. Conversely, Sign D is inappropriate as a warning sign because of the strong individual differences in understanding. This suggests that the shape and color of a sign as indicating the intention of an automated vehicle should be determined by who is looking at the sign. In the case of this study, the use of footprints may have encouraged pedestrians to take the correct action.

4. CONCLUSIONS

In this study, we examined the colors and shapes of signs that are easy for pedestrians to understand and not easy for them to mistake. The results showed that signs indicating pedestrian and vehicle behavior were valid regardless of gender and age. A more detailed study will have to be conducted in the future. To this end, the direction of the signs, the hours of posting and the location will be adjusted. In addition, we will develop a next-generation road environment design that utilizes this research.

ACKNOWLEDGEMENTS

This study was supported by a Grant-in-Aid for Scientific Research (JP18H03480).

REFERENCES

HASHIMOTO, S., NISHIURA, T. & MIURA, Y., 2015, *A Study on the Color Paving for Traffic Calming*, Transactions of the City Planning Society of Japan, 50(3), 715–722.

NAKAGAWA, T., MIYAGAWA, A., TANIGUCHI, A., IRYO, M., KOJIMA, A. & FUJII, S., 2017, *Study on Effects of Road Space Design on Communication between Pedestrian and Driver*, Journal of Traffic Engineering, 3(4), A_84–A91.

NISHIKAWA, K. & YAMAMOTO, S., 2011, *Research on Shared Space, part 1: Concept of Shared Space*, Proceedings of the Annual Conference of JSSD, 58, 131–132.

OZAKI, T., YAMAMOTO, S., ITOH, M. & KAWAMOTO, M., 2017, *Road Surface Design to Reduce Travel Speed: A Design Proposal for Shared Spaces*, Proceedings of the Annual Conference of JSSD, 64, 272–273.

TAKATORI, H., ENZAKI, Y., YANO, H. & IWATA, H., 2016, *Development of A Large-Immersive Display "LargeSpace",* Transactions of the Virtual Reality Society of Japan, 21(3), 493–502.

YAMAMOTO, S. & NISHIKAWA, K., 2011, *Research on Shared Space, part 2: Field Study of Shared Space*, Proceedings of the Annual Conference of JSSD, 58, 133–134.

Address: MAEDA Moe, Master's Program in Art and Design, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki Prefecture, 305-8574, Japan
E-mail: filulia0611@gmail.com