Influence of Road Surface Design on Vehicles' Speed: Experiment Using Driving

Influence of Road Surface Design on Vehicles' Speed: Experiment Using Driving Simulator for Implementation of Shared Space

Takuma OZAKI,[1] Sari YAMAMOTO,[2] Makoto ITOH,[3] Masayuki KAWAMOTO[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] Headquarters for International Industry-University Collaboration, University of Tsukuba

ABSTRACT

We studied the influence of road surface design on vehicle speed with the aim of implementing Shared Space on Japanese roads. We created 16 road designs and subjects indicated what they felt was an appropriate speed on each road design using a driving simulator. Results of the experiments show that diagonal intersection patterns have the strongest deceleration effect, and horizontal lines along driving direction have the strongest acceleration effect.

1. INTRODUCTION

Japan is one of the most rapidly aging societies in the world, and a new transportation system is therefore necessary to meet changing societal needs in the future. We focus on "Shared Space" as a concept that can meet these needs. Shared Space is an urban design approach in which motor vehicles, pedestrians, and bicycles share the road space. The concept was developed by Hans Monderman, a traffic engineer in the Netherlands. Shared Space has become popular in the EU and other regions, but it has never been popular in Japan. To implement Shared Space, we should design road spaces from various viewpoints. Among these, we focus on vehicle deceleration in this research. The purpose of this research is to reveal the influence of road surface design on vehicles' speed and the design elements that can cause drivers to decelerate.

2. METHOD

We used the "UC-win/Road Ver.10 DS" driving simulator to examine designs that would influence vehicle deceleration, specifically road pavement design. Subjects watched the monitor, which simulated driving on roads of various designs (Figure 1).

Figure 1: Experiment design

The experimenter gradually accelerated the driving speed, and the subjects raised their hands when the speed reached their favorability. If the speed was too high, the subject could decelerate by instructing the experimenter. Only the experimenter could see the speed indicator. We therefore determined participants' preferred speed for each design.

3. ROAD DESIGNS

We created 16 road design patterns (Table 1). The road design patterns presented design elements that possibly influence velocity perception such as angle, brightness, and size of the patterns, or different pavement materials.

Table 1. Road designs used in the experiment

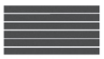
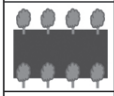
Image	No.	Design Elements
	A	asphalt, center line 6 meters wide
	B	asphalt, center line 4 meters wide
	C	asphalt, no line 6 meters wide
	D	asphalt, no line 4 meters wide
	E	asphalt horizontal lines along driving direction 6 meters wide
	F	asphalt vertical lines along driving direction 6 meters wide
	G	asphalt diagonal intersection pattern 6 meters wide
	H	interlocking block horizontal lines along driving direction 6 meters wide

Image	No.	Design Elements
	I	interlocking block vertical lines along driving direction 6 meters wide
	J	interlocking block diagonal intersection pattern 6 meters wide
	K	interlocking block diagonal intersection pattern (low contrast) 6 meters wide
	L	interlocking block diagonal intersection pattern 6 meters wide
	M	interlocking block diagonal intersection pattern (large size) 6 meters wide
	N	interlocking block diagonal intersection pattern (small size) 6 meters wide
	O	asphalt, high trees 6 meters wide
	P	asphalt, low trees 6 meters wide

4. EXPERIMENT DETAILS

4.1 Subjects

The subjects were 30 people who had driver's licenses. They were divided into three age groups of 10 people: those in their 20s, those aged 45–55, and those aged 65–75 (Table 2).

Table 2. Subjects

	20s	45–55	65–75	Total
Male	5	5	5	15
Female	5	5	5	15
Total	10	10	10	30

4.2 Date and Place

Date: March 10, 2017 – April 7, 2017

Place: Empowerment Studio, University of Tsukuba, Tsukuba, Japan.

4.3 Experimental Procedure

1. Subjects fill in the factsheet (age, sex, eyesight, years of driving experience)
2. Experimenters explain the experiment
3. Several test drives on Road A (white line on the center of the asphalt surface)
4. Main experiment (one drive on each of the roads; roads are presented in random order)
5. Subjects write impression of the experiment

5. RESULTS

There was one outlier in the experiment data, so we analyzed 29 subjects' data except for those of subject No. 10 (male aged 65–75). Figure 2 shows the averages of all subjects' and each generation's driving speeds. The driving speed becomes lower towards the right. Therefore, the leftmost design has the strongest acceleration effect, and the rightmost design has the strongest deceleration effect.

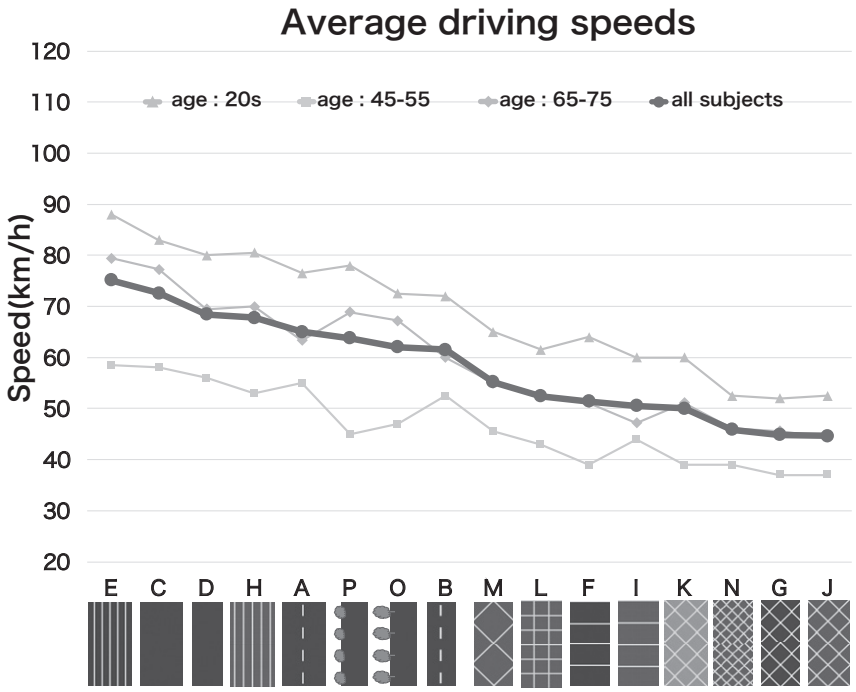


Figure 2: Average driving speeds

Road E (horizontal lines along the driving direction on asphalt surface, as shown in Figure 3) had the strongest acceleration effect, and Road J (diagonal intersection patterns on interlocking blocks, as shown in Figure 4) had the strongest deceleration effect. The average driving speed on Road E was 75.2 km/h, and on Road J was 44.7 km/h. Diagonal intersection patterns highlight the perception of driving speed and have a high deceleration effect. Horizontal lines parallel to the driving direction weaken the perception of driving speed and have a high acceleration effect.

Figure 3: Road E

Figure 4: Road J

Table 3 shows the difference that each design element had on vehicle speed. It shows that line direction and pattern size have significant effects on driving speed ($p<0.01$). In the case of roads with the same patterns and different pavement materials, such as E and H, F and I, and G and J, the speed on interlocking road was lower than that on asphalt road, though these show no significant differences. The youngest and oldest subjects showed a higher speed tendency, and the middle-aged subjects showed a lower speed tendency.

Table 3: Differences in driving speed according to design element

Design element	Roads	Difference	
Road width	A⇔B	0.24	-
	C⇔D	0.24	-
Center line	A⇔C	0.09	-
	B⇔D	0.09	-
Line direction	E⇔F	0.00	**
	F⇔G	0.08	-
	E⇔G	0.00	**
	H⇔I	0.00	**
	I⇔J	0.06	-
	H⇔J	0.00	**
Pattern contrast	J⇔K	0.12	-
Pattern angle	J⇔L	0.03	*
Pattern size	J⇔M	0.01	**
	J⇔N	0.37	-
	M⇔N	0.01	*
Pavement material	E⇔H	0.11	-
	F⇔I	0.43	-
	G⇔J	0.48	-
Trees	C⇔O	0.04	*
	C⇔P	0.08	-
	O⇔P	0.39	-

T-test *: $p<0.05$; **: $p<0.01$; -: n.s.

6. CONCLUSIONS

This study revealed that road design influences driving speed. Diagonal intersection patterns have a high deceleration effect. Design elements such as line direction, pattern size, and road surface significantly influence driving speed.

In future research, we will clarify design elements and effects that create safe road spaces, and conduct a demonstration to show how Shared Space can be implemented.

REFERENCES

Nishikawa Kiyoshi, Yamamoto Sari, 2011, *Research on Shared Space, part 1: Concept of Shared Space*, Proceeding of the 58th Annual Conference of JSSD, 132-133

Nishikawa Kiyoshi, Yamamoto Sari, 2011, *Research on Shared Space, part 2: Field Study of Shared Space*, Proceeding of the 58th Annual Conference of JSSD, 134-135

Address: Takuma OZAKI, Master's Program in Art and Design, University of Tsukuba
1-1-1 Tennodai, Tsukuba, Ibaraki 305-8574, JAPAN
E-mail: ozaki.tf@gmail.com