The Relationship between Speed Perception and Road Safety
- An Attempt to Establish the “Illusion Engineering” -

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Abstract: Designers try to make the human environment more comfortable when creating their designs, and they have to examine the environmental elements in relation to human perception or human information processing. As typically seen in visual illusion, perception does not necessarily correspond to the physical or objective nature of things. Many studies on visual illusion have shown that configurational characteristics influence our perception. Speed illusion is one of the illusions observed for an object in motion and/or an observer in motion. Our previous study has demonstrated that configurations of road surface patterns affect speed perception. The present study examines more systematically what factors influence the speed perceived by drivers in the road scene through simulation experiments. Four different configurations of traffic lanes were used as test animations: straight center lane, straight right lane, curved center lane, and curved right lane. These test animations were randomly presented. Participants were asked to estimate the perceived speed of motion in the test animation, using the method of magnitude estimation. Configurational characteristics in the field of vision were found to affect speed perception, which could be used as cues to make drivers naturally slow down. This finding suggests the importance of a new approach called the “illusion engineering” which will be one of the effective countermeasures for speeding. When designers create road surface patterns to prevent accidents due to speeding, they should make use of this “illusion engineering.”

Key words: Environmental Elements, Illusion Engineering, Speed Perception, Visual Illusion

1. Introduction

Everyday things are not isolated from each other, and are not always static. They have various shapes, forms and colors, and sometimes they move or observers move. One shape is often seen together with other shapes. Visual perception includes shape perception, size perception, illusion, motion perception, and speed perception. Recently, it has been proposed that designers try to make the human environment more comfortable when creating their designs, and that they should examine the environmental elements in relation to human perception or human information processing. For example, design psychology, human engineering design, barrier-free design, kansei engineering design, and interface design should mainly be based on perceptual-cognitive psychology. In other words, psychological studies in these areas are very effective for better design. Especially, this kind of approach is very important when design is concerned with road safety.

In general, the road traffic environment is composed of focal or figural stimuli with various shapes in the
background. These figural and background stimuli are perceptually organized as a whole, and perceptual properties of the figural elements, e.g. perceived motion and speed are influenced by configurational characteristics of the background. According to Denton (1977) [1] and OECD (1976) [2], speed perception is crucial in preventing road accidents by drivers. Denton reported that configurational characteristics of the road surface influenced speed perception so that drivers overestimated the speed of their vehicles, and unintentionally slowed down. Our previous study (Kim & Noguchi, 1998) [3] found that the effects of spatial intervals and the width of figural components in the test patterns were selective in different configurations. It seems that these selective effects would be due to the relation between the orientation of figural components and the direction of motion.

The present study investigates how the most emergent shape of the real road influences the perceived speed. In Experiment I, the effect of the shape of road surface pattern on the perceived speed or speed illusion was tested by the rank order method [4] using the simulated road scenes. In Experiment II, the shape effect on speed illusion was examined with the magnitude estimation method [5]. The outcome of the present study is expected to find out some important factors useful for a successful road environment design, and will be the first step to establish the “illusion engineering”.

2. EXPERIMENT I

The road environment contains objects with various shapes which influence the driver’s perception of the vehicle speed. It has been reported that some shapes of patterns the road surface cause so-called “speed illusion”[1]. The purpose of Experiment I was to examine how the perceived speed or speed illusion was affected by changing the shape of patterns on the road surface.

2.1 Method

2.1.1 Participants

Twenty-two design psychology students, 14 men and 8 women, participated in the experiment. They had normal or corrected-to-normal visual acuity, and had experience in similar tasks given in this experiment. Participants compared the perceived speeds of four different animations using the method of rank order.

2.1.2 Stimulus Materials and Procedure

Four different configurations of real traffic lanes were used as the test animations for road scenes. In each of the four test animations, the road shape (straight or curved) and the observer’s position (center or right lane) were the experimental variables: CS (straight center lane), RS (straight right lane), CC (curved center lane), and RC (curved right lane). The speed and size of the test animation were kept constant. As shown in Figure 1.1, the four road scenes were positioned in the 2 x 2 window in a randomly selected order. The height and width of the entire display window were 8 and 10 degrees in visual angle, respectively. Each test animation was displayed on a monitor (SONY Multiscan G520 ) operated by a personal computer (Mac G4) with Premiere 6.0J. Viewing distance was approximately 60 centimeters from a chin-rest. Each participant was asked to rank the scenes in the order of perceived speed.

2.2 Results and Discussions

Figure 1.2 shows the results obtained with the method of the rank order. It is clear from Figure 1.2 that the difference in the configuration of road components influenced the speed of motion perceived by observers even though all of the test scenes moved with the same speed. It has also been found that the relationship between the
orientation of road components and the direction of motion is critical in determining the perceived speed.

As shown in Figure 1.2, the lane position (RS, RC, CS, and CC) seems to influence speed perception of the test animation. It was found that the amount of speed illusion was greater for the right lane than for the center lane. These results suggest that the figural relationship between the road lane and the components in the road environment would be critical in determining speed perception, and that the extent or perimeter of these components influences the speed perceived by observers.

3. EXPERIMENT II

The results of Experiment I obtained by the method of rank order are qualitative in nature or non-parametric, and hence cannot be quantitatively applied to environmental design on the real road. Thus, Experiment II investigates the effects of road shape on speed perception using the method of magnitude estimation with which the perceived speed can be measured quantitatively.

3.1 Method

3.1.1 Participants

Twelve subjects, six men and six women, participated in this experiment. They had normal or corrected-to-normal visual acuity, and had experience in participating in similar kinds of experiment.
3.1.2 Stimulus Materials and Procedure

The test animations consisted of four different configurations of traffic lanes: RS (straight right lane), RC (curved right lane), CS (straight center lane), and CC (curved center lane). For each test animation, the actual speed was the same. Figure 3.1 shows examples of the test animations. The standard animation was always CS, whereas the comparison animation showed an animation randomly selected from RS, CC or RC. The height and width of each test animation was 11 and 14 degrees in visual angle, respectively. The standard and comparison animations were displayed simultaneously on a monitor (SONY Multiscan G520) operated by a personal computer (Mac G4) with Premiere 6.0J. Viewing distance was approximately 58 centimeters. The numeral 100, as a modulus, was assigned to the perceived speed of the standard animation. Participants were asked to compare the standard animation (left) with that of the comparison animation (right) and assign a number for the perceived speed of the comparison animation relative to the modulus. This procedure was replicated three times, and the participant’s introspection for their estimation was recorded.

3.2. Results and Discussions

As shown in Figure 3.2, the speed perceived by observers was found to be different among different road scenes, even though the test animations moved with the same speed. It was also found that the speed in the right lane tended to appear faster than in the center lane for both straight and curved roads. Observers pointed out in their introspection that the presence of elements on the road surface and roadside such as painted stripes and trees affected their speed perception. As seen in our previous study using a two-dimensional animation (Kim & Noguchi, 1998), the larger overestimation of speed occurred with patterns consisting of elements perpendicular to the direction of motion. From the comments or introspections made by the observers, it is apparent that the same process was at work in Experiment II. In the three-dimensional perspective, the trees and other roadside elements perpendicular to the direction of motion entered the observers’ field of vision much more in the right lane than in the center, resulting in perceiving higher speed. This seems to be closely related to the effect of motion perception in peripheral vision [6].

These results suggest that the figural relationship between the road lane and the components in the road environment are critical in determining speed perception, and that the extent or perimeter of components of the road environment influences the speed perceived by observers. Furthermore, the interval between shapes determines speed perception: shorter intervals facilitate an overestimation of speed. Also, the relationship between the spatial orientation of road components and the direction of motion is one of the most important
factors determining the perceived speed. Analysis of variance applied to each of the road shapes revealed that the main effect of the road shape was significant for speed perception ($F(2, 22) = 9.493, p < .001$).

![SPEED ILLUSION](image)

**Figure 3.2 Results Obtained by the Method of Magnitude Estimation**

4. Conclusions

The results of the present study clearly demonstrated that different road shapes or configurations induced different perceived speeds. Generally, the presence of objects with some figural characteristics such as trees and other roadside components facilitate speed overestimation. This means that speed perception can be influenced by the relationship between the orientation of figural components to the direction of motion within the peripheral vision of the observer. The present study implies that the design of roadside environments needs to take into consideration the effects explained above that are one of the most important issues relevant to road safety.

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References