Sequence Pattern Design of Long Tunnel to Improve a Monotonous Environment

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Abstract: Traffic Accidents from drowsiness are often caused by the deterioration of drivers’ concentration. Drowsiness results from a monotonous driving environment. Long tunnels are problematic in that they feature long stretches of monotony. New inner tunnel pattern designs can stimulate drivers and relieve the stress of such environments. This case study, featuring extensive field research of the Odori tunnel as well as a CG driving stimulation, will address two key design specifications. 1) The tunnel’s design pattern should catch the observer’s attention. 2) The tunnel’s design pattern should feature a story to capture the observer’s imagination. Based on these observations a new tunnel design pattern will be presented.

Key words: Tunnel scenery, Pattern design, Sequence design

1. Introduction
One of the many pleasures of driving is the constant change of scenery. This often keeps drivers alert. However, in a monotonous long tunnel, drivers’ attention often tends to deteriorate as drowsiness can lessen driver’s response time, which in turns lead to accidents. In this study, I suggest the most effective sequence design to improve a monotonous tunnel environment.

2. Survey of the Odori Tunnel
2.1 Literature Search
For the purpose of comfortable driving, a sequence pattern design was adapted for the Odori tunnel in Chubu Jyukan expressway in Japan [1]. This is the first such case in the world. Sequence design refers to a specific design that changes intermittently over time. The design of the Odori Tunnel starts with long lines of colored tiles in the entrance area, while changing gradually into shorter lines around the middle area (figure 1). The 4.3 km targeted tunnel is sloped.
Design objectives of Odri tunnel:
1) To reduce the stress of driving inside a tunnel
2) To prevent speeding on the downward slope.
The road administrator study asked the question [2]: “How did you feel about the changing pattern in the wall design?” Of the 1,189 answers collected, 54% said they did not feel any change. While 46% said they felt some change of design. The study featured a written comments section, with the majority responding: “I enjoyed
driving in the tunnel and the pattern’s design was comfortable.” However, the second most common written comment was “I did not notice any change in the pattern” (figure 2). It would be better if the design had more of a dramatic change, and it would have been better if it had a wider variety of patterns. From this feedback, it was concluded that the tunnel’s pattern design should be more dramatic and noticeable.

2.2 Field Study

In July 2008 the impressions of drivers of the Odori tunnel were examined. The author, along with three students observed the tunnel. Some comments on the tunnel’s pattern design revealed, “Driving was more fun and less stressful than driving without the pattern,” and “The colorful lines/patterns were bright and enjoyable,” while other comments claimed, “The tunnel was too dark to discern any change in pattern.” The observers recommended an improvement in luminosity and chroma and felt that the middle section needed to be less distracting.

3. Proposal on Design Sequence Improvements

3.1 A Case Study of a Tunnel

Tunnel settings of the wall design: Two lane highways going opposite directions, Tunnel length of 3000m, Tunnel speed limit of 80km/hr, Use of a high-pressure sodium lamp, Tunnel’s sidewalls painted white.

3.2 Concept and Pattern Design

D. Appleyard, et al. suggested “there needs to be a contrast and change in the road design.” “Tempo and rhythm are the keys to the all sequences.” [3].

After these observations, a dramatic change of design was implemented in the pattern’s design. A 3 km length tunnel was designed with a story pattern that featured; a beginning, a build up, a climax, and an ending. The tunnel’s target area (side view) was divided into respective sections while a pattern, shape, and color story was designed to keep the driver’s attention [4].

For observers to feel the illusion of an animation type movement 3 factors must be addressed:

1) Pattern size: The size of the pattern should change.
2) Vertical arrangement: The location of the individual patterns should move up and down.
3) Proximity: The location of the individual patterns should be close.

On the basis of these facts, a new conceptual pattern was designed. It is showed in figure 3.
This section is characterized by an absence of pattern in the beginning, allowing the observer to feel comfortable in the new environment. Gradually light green rectangles appear and change to dark green rectangles. The vertical pattern remains constant.

The driver begins to find interest in the pattern as the shapes change from rectangles to squares.

In order to prevent this section's monotony, the patterns were designed to be “unpredictable.” To recognize the pattern easily, the changing pattern will move vertically. Simultaneously, to prevent the patterns from distracting drivers the color of the pattern will change gradually into lighter color and then slowly disappear. The pattern will then reemerge into a different color and becomes a quality which is unpredictable.

The driver should be losing interest in the tunnel’s patterns. To encourage the driver’s disconnection from the tunnel’s pattern, the new sequence should become more predictable. The individual patterns should change from squares to rectangles, high to low luminosity, and then gradually disappear.

Figure 3 Story Narrative and Sequence Pattern Design

Figure 4 Scene of Sequence Pattern Design
3.3 Evaluation by the Computer Graphic Simulation

A CG drive simulation device was built in order to confirm whether drivers could drive the designed tunnel comfortably. The software, UC-win/road made in FORUM8 was used for this examination. GT-FORCE Pro controllers; a steering wheel, an accelerator, and a brake were all made by Logicool Company.

Two tunnels; one with and one without the design on its wall, were examined (Figure 4). Trial subjects were twelve university students learning Design; all were experienced male drivers. After the experiment, the driver’s impressions of the tunnel with the pattern design were compared to the tunnel without the design. The results were recorded in Figure 5. The questionnaire had 3 items which were Easiness of driving, Comfort of driving, and avoid getting tired. In the experiment, 17% of subjects felt it was difficult to drive on the tunnel with the patterns. However, 100% of subjects had a good impression in categories Comfortable driving and Avoid getting tired. Therefore from this result the logical story pattern design is quite effective.

4. Conclusions

In this study, I suggested the most effective sequence pattern design which features a logical story pattern to improve a monotonous environment. The effectiveness was conformed by extensive CG driving simulations. The questionnaire showed that some subjects felt distracted by the pattern and further study is necessary to improve the design which makes an optimal driving condition enhanced, along with improving the CG driving simulation.

Since the designed tunnel wall is easy to be replicate by painting, I hope this study contributes to the safety of the tunnel space and the improvement of its scene.

5. References and Citations