Practical optimal signal control emphasizing pedestrian road crossing realities

1. Background and goals

Currently, pedestrians do not sufficiently understand the meaning of the signals at pedestrian crossings, and as a result, actual pedestrian behavior is not necessarily the same as that assumed by traffic laws. This has been noted as one factor accounting for pedestrians not completely crossing the road by the time crossing signals turn red, affecting traffic safety and smoothness by causing complications with vehicles turning left or right.

This study is a report of an actual road experiment in which we investigate and analyze changes in pedestrian road-crossing behavior after mounting auxiliary equipment to a traffic signal that allows pedestrians to clearly understand the amount of time remaining to cross the road.

The experiment first evaluated the effect of displays indicating time remaining for road crossing by analyzing videos of an actual crosswalk. We then performed an experiment in which music by the composer Keiichiro Shibuya was played during road crossings as a method of promoting behavioral change in pedestrian psychology.

2. Research content

2-1. The effect of installing crossing signals with countdown displays

We installed crossing signals with countdown displays as shown in Fig. 1 at actual pedestrian crossings, and evaluated their effect in a pilot survey (Table 1).

Figure 2 shows changes in the ratio of pedestrians who did not complete road crossing by the time

Figure 1. Pedestrian crossing signal with countdown display

Table 1. Evaluation by pilot survey (2005)

Item	Description
Experimental intersections	Tokyo: Ginza 2-chome, Ginza 5-chome, Omori Yokohama: Honcho 1-chome, MM2
Experimental period	9 December 2005 (Friday) - (about 2 months)
Survey and observation period	Before the experiment: 18, 25, 28 November 2005 During the experiment: 14, 16, 19 December 2005
Investigation methods	Videos: 3000–8000 pedestrians at each intersection Surveys: About 100 pedestrians at each intersection

Project Leader: Masahiko Katakura
Professor Emeritus, Tokyo Metropolitan University

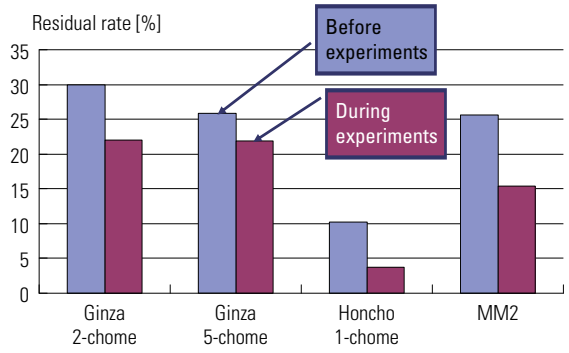

Figure 2. Effects of countdown display

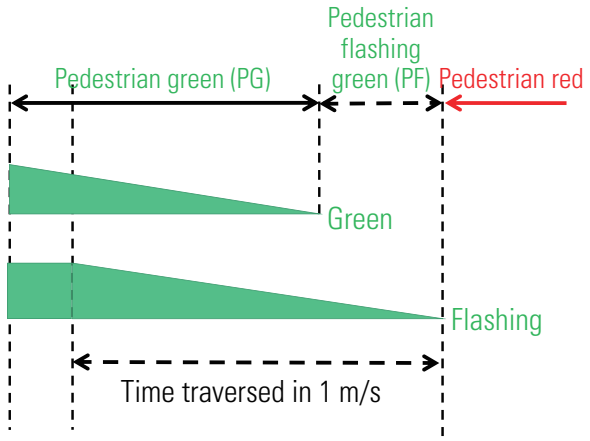

Figure 3. Green completion and green flashing completion methods

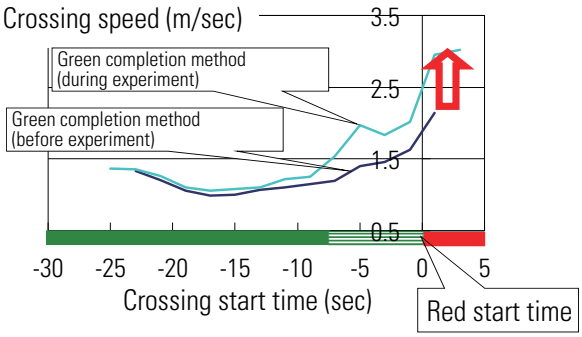

Figure 4. Change in crossing speed

the signal turned red (the residual rate) at each crossing with a countdown display. In all cases, we verified a reduction in the residual rate ranging from a few percent to as much as 10%.

Figure 3 shows the results for two types of countdown, a "green completion method" that shows the decreasing amount of remaining time and a "green flashing completion method" that shows the end of the crossing period. Both had approximately equal effects in reducing the residual rate. However, as shown in Fig. 4, the green completion method saw a rapid increase in pedestrian crossing speed during the latter half of the crossing, indicating the possibility that pedestrians feel rushed. In contrast, there is no significant difference in speed between the former and latter half of crossing when using the green flashing completion method. We presume that this is due to a reduction in the number of pedestrians who started crossing later than they should; therefore, we consider the green flashing completion method to be superior.

The results of a survey indicated that with the exception of young people (age 13 to 24 years), over 80% of pedestrians who understood the meaning of the countdown display found it helpful. We also found that placing the countdown display and the pedestrian crossing icon on separate panels (Fig. 1) increased the recognition rate of the display among pedestrians, as compared to when the icon and display were shown together.

In 2006, we experimentally installed these crossing signals at four intersections (Ginza 5-chome, MM2, Ginza 4-chome, and Tsurumi Keisatsusho-mae) for pedestrian crossings ranging from 13 to 38 m in length, conducted a questionnaire, and performed video observations of approximately 16,000 pedestrians. Results of the questionnaire performed at the MM2 and Ginza 4-chome intersections were largely positive in terms of the subjective evaluations by pedestrians. However, a statistically significant reduction in the number of pedestrians not completing road crossing by the time the signal turned red was seen only under the green flashing completion method at the Ginza 4-chome intersection; no effect was

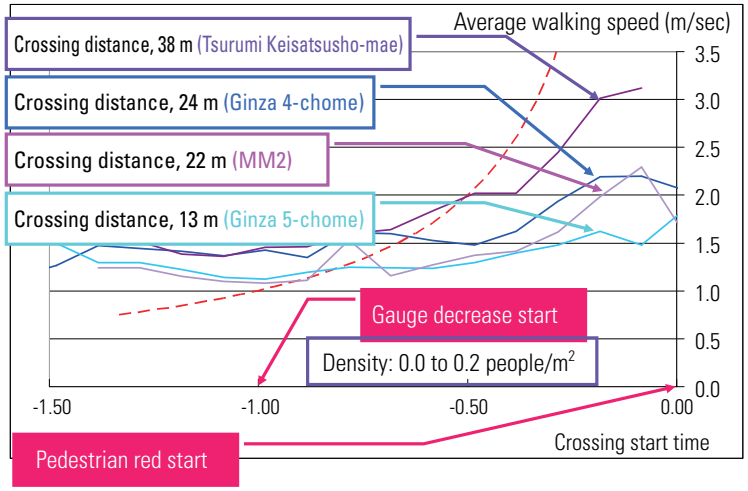

Figure 5. Crossing distance and average crossing speed (during green flashing completion)

verified at the other intersections. Yet, we were able to confirm a significant increase in pedestrian walking speed, which was proportional to the length of the crossing, in the second half of the crossing (Fig. 5).

2-2. The effect of installing crossing signals with audible cues

We installed crossing signals with audible cues, which played music when the signal was green, to investigate whether the installation changed pedestrian crossing behavior by psychologically promoting an increased crossing speed when there was little time remaining to cross, and by preventing pedestrians from initiating crossing when the green signal was flashing. The music played was composed by Keiichiro Shibuya, an established Japanese musician.

The three compositions respectively aimed at promoting a comfortable walking pace, increasing crossing speed, and warning pedestrians to prevent intrusion into the crossing. The trumpet-type speakers that can be installed into pedestrian crossing signals are very limited in the range of frequencies and waveforms they can produce, so compositions that would be easily remembered and not tiresome under these conditions had to be produced. In other words, the compositions could not simply be sinusoidal waves such as the loud tone played when a television station is off the air, but rather had to successfully employ square waves for attacks and reverberations to present a rich sound that could be clearly heard.

Table 2 shows an overview of the investigation and the obtained data. As Table 3 shows, the residual rates over all measurement times were 18.7% without music, but fell to 13.9% when the music was played, representing a statistically significant decrease. We found no difference in the time that pedestrians initiated crossing after the light turned green based on the presence or absence of music; however, there was a difference in the time that pedestrians completed crossing when music was played. This indicates that the music decreased the residual rates. As Fig. 6 indicates, this is due to an increased

Table 2. Overview of investigation and the acquired data

Observation location	Music	Video date	People crossing
Ginza 4-chome	None Yes	30 October 2007 (Tuesday) 18 March 2008 (Tuesday)	1929 1804

Table 3. Residual rate and remaining time

Music	None	Yes
Crossing count [people]	1929	1804
Residual amount [people]	361	251
Residual rate [%]	18.7	13.9
Average remaining time [sec]	5.3	4.4
Maximum remaining time [sec]	16.3	18.8
Significance		0.037

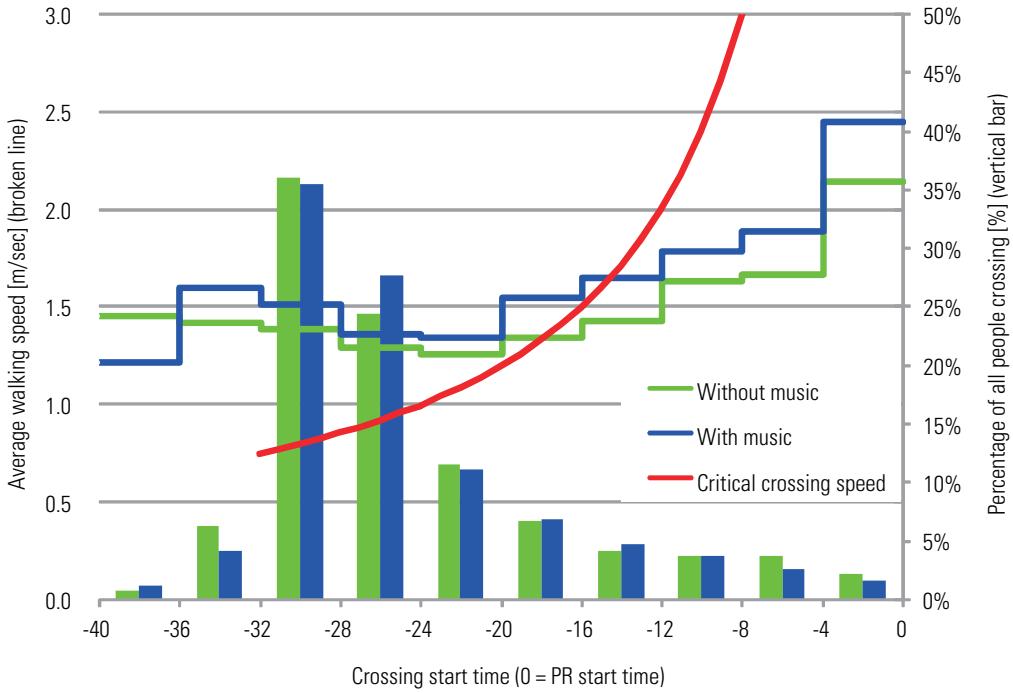

Figure 6. Average walking speed at crossing start time

crossing speed. Furthermore, we found that overall, the presence of music prevented approximately 40 people from prematurely starting to cross. We verified a similar effect in an investigation of an intersection at Shin-Yokohama 2-chome.

3. Conclusions

The pieces of music by Mr. Shibuya that were used in the present study were composed with the goal of being easy to remember and hum along to, and were clear, distinctive, and easily heard over the sound of traffic. It is likely that pedestrian crossing signals that play such music are not only accepted more easily by pedestrians, but also exhibit tangible effects of reduced residual rate and increased walking speed, providing an effective improvement to current crosswalk walking behavior.

4. Future outlook

This research indicated that pedestrian crossing signals equipped with appropriate music-playing functionality can lead to proper pedestrian crossing behavior. We hope that future studies will verify the effectiveness of crossing signals with audible music cues under a variety of road and traffic conditions and in various acoustic environments, and that the installation of such equipment at many intersections will aid efforts to improve pedestrian safety and smooth traffic.