Influence of Repeated Experience on Unsignalized Intersection Crossing Behavior of Drivers without   Right-of-way

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1 Introduction

Collisions at intersections account for more than 50 percent of total traffic accidents in Japan [1]. The most common cause of these incidents is human error. Therefore, understanding the nature of driving behavior at intersections is essential for developing and implementing accident prevention measures.

This study aimed to examine the influence of a driver's repeated experience with crossing un-signaled intersections without the right-of-way. Specifically we examined the change of start position, identified as a point where drivers step on the gas pedal immediately prior to entering intersections. Also we assessed the relationship between driving behavior at intersections and responses to a Driving Style Questionnaire (DSQ) [2].

Repeated experience often leads to habituation, and driving behavior is no exception to this [3]. For instance, many drivers begin to drive faster on narrow streets as they gain experience [4]. At the same time, there is a real possibility that drivers acquire proficiency through experience. In the interests of improving traffic safety, this study aimed to describe the nature of changes in driving behavior as drivers experience repeated encounters with interactions.

2 Data Preparation

A vehicle equipped with sensing devices [5] was used to measure driving behavior. Devices included instruments that sensed a driver's operational behavior, such as steering wheel operation, and instruments designed to detect vehicle condition, such as speed of travel. Data from sensors attached to pedals detected pedal presses for both acceleration and braking whereas speed data was obtained from sensors on the front wheels.

First subjects received an outline of the experiment and their consent was obtained. Next, drivers' crossing behaviors without right-of-way was recorded at un-signaled intersections in a residential area of Tsukuba, Japan (Table 1). Eight subjects drove the vehicle on each intersection six times a day for six successive weekdays, leading to a total of 216 trials. Following this, all subjects completed the Driving Style Questionnaire (DSQ).

The data used in the following analysis were not influenced by other traffic. The ethics committee of National Institute of Advanced Industrial Science and Technology (AIST) approved this experiment.

Table 1. Properties of intersections. All intersections are cross streets. Fair visibility means that drivers have some visibility as the buildings on the left and right corners are set back from the road.

Intersection	Visibility Left	Right	Road width Own	Cross	Distance from the nearest edge of the cross lane to stop line [m]
I1	Bad	Fair	5.	6.4	3.8
I2	Fair	Bad	5.	6.4	2.7
I3	Bad	Bad	5.	6.4	3.0
I4	Bad	Bad	5.	6.4	4.6
I5	Fair	Bad	5.	6.4	4.7
I6	Fair	Fair	6.4	6.4	10.8

3 Analysis

Typically intersection crossing behavior consists of deceleration, safety confirmation, and acceleration [6]. Sometimes, drivers do not enter an intersection during the first acceleration. After the preliminary acceleration, they decelerate to confirm the intersection is safe. In this study, start positions, are identified as points where drivers press the gas pedal just before entering intersections. These positions were examined in this study and were measured by calculating the distance of the car (at this point) from the nearest edge of the cross street.

In addition to the actions above, pedal operation patterns were examined. Four patterns were defined here: PS, PD, PR, and PL. PS indicates that, in most cases, drivers release the brake-pedal, move their foot to the gas pedal, and then press the gas pedal only once before entering intersections. PD means that drivers step back on brake-pedal at least once after moving their foot to the gas pedal. PL means that drivers change their patterns of pedal use from PD to PS through experience. PR means that drivers change the patterns arbitrarily between PS and PD.

4 Results

Table 2 shows averaged start position of the last three trials for each intersection. The figures in parentheses are correlation coefficients of start positions and number of times a driver crossed intersections throughout the study: only coefficients of 0.6 or greater are shown. A positive value means that a start position increased in distance from a cross street through experience, and a negative value indicates a decrease. Table 3 shows pedal operation patterns for each intersection. Table 4 shows categorization results of repeated intersection crossing behavior with starting positions and pedal operation patterns.

Table 2. Averaged starting positions [m] (the distance from the nearest edge of the cross street) of the last three trials. Inside of parentheses are correlation coefficients throughout the study of each start position and the number of times a driver crossed intersections.

Subject	Intersection I1	I2	I3	I4	I5	I6
S1	n/a	1.3(0.9)	2.7 (0.8)	2.3	2.7	3.8
S2	0.8	0.0	1.6	0.9	0.4	2.8
S3	-0.2	0.0	1.0	0.3	-0.6	1.1
S4	0.1	-1.0(-0.8)	0.7	-0.7(-0.7)	-0.6	2.8
S5	2.1	1.0	3.0(0.7)	1.3	1.7(0.8)	4.5
S6	2.1(0.6)	0.7(-0.6)	3.0	0.9	1.0(-0.7)	2.8
S7	0.8(-0.6)	1.0	1.0	0.9	1.0	4.8
S8	1.5	2.0	2	0.9	1.0	1.8

Table 3. Pedal operation pattern through experience.

Subject	Intersection I1	I2	I3	I4	I5	I6
S1	n/a	PL	PS	PL	PS	PL
S2	PR	PR	PR	PR	PR	PR
S3	PS	PS	PS	PS	PS	PS
S4	PS	PS	PS	PS	PS	PS
S5	PR	PR	PR	PR	PR	PD
S6	PS	PS	PS	PS	PS	PL
S7	PS	PL	PL	PL	PL	PL
S8	PS	PS	PS	PS	PS	PS

Table 4. Categorization of crossing behavior with start position and pedal operation pattern.

Distance from the cross lane to start position	Pedal operation pattern PD or PR	PL	PS
Increase with Experience (IE)	S5	S1	
Not change (NC)	S2	S7	S3 S8
Decrease with Experience (DE)			S4 S6

5 Discussions

Subjects were categorized into three groups according to changes of starting positions over trials (experience): Increase with Experience (IE), No Change (NC), and Decrease with Experience (DE). They were further subdivided into three orthogonal groups based upon their consistent pedal operation pattern: PS, PL, and other (PR or PD).

The above two categorizations showed some correlations (Table 4). All subjects in IE did not appear in PS, and all subjects in DE belonged in PS. Scores of DSQ scales given by each subject were examined between IE and DE using linear regression. Results also showed that the two drivers assigned to the DE category scored high on the following scales of this questionnaire: Methodical driving, Moodiness in driving, and Preparatory maneuvers at traffic signals.

The starting position and the degree of change in the starting position were correlated. When the starting position was relatively close to the edge, participants tended to decrease the distance between the starting position and the edge.

The intersection I6 showed relatively greater start position for all subjects because the road that the drivers approached the intersection on was wide, and the distance from the cross street to the stop line was relatively large [7].

References

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Figure 1. Typical intersection in a residential area of Tsukuba, Japan