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Drivers' reaction time towards red-light timing at urban intersections

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Abstract

The study aims to explore the drivers' reaction time influenced by the red-light timing at urban signalized intersections. The red-light timing ranges from 40 seconds, 60s, 80s, 100s, and 120s. E-prime is used to simulate the signalized intersections and measure the drivers' reaction time to the onset of green-light. 30 undergraduate drivers are involved and the data is analyzed in SPSS 17.0. The results show that 80 seconds is the maximum timing for waiting for the red light as compared to other four timings in the way of shortest reaction time to the onset of green light. It is therefore suspected that the span of 80 seconds is the cut-off timing for the red-light waiting at the intersections.

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Key words: red-traffic light , waiting timing , driver reaction time

Foreword

The red-light timing at urban signalized intersections is the test of level on traffic road users' patience and traffic safety awareness. There are certain restrictions on red-light timing setting in the traffic intersections in every country. Germany is 60 seconds and Britain is 45 seconds [1]. In China, there are certain basic principles on red-light timing setting that mainly depend on the road traffic flow index and signal cycle phase to co-ordinate the distribution of red-light timing on the road of different natures. In this way, the distribution of red-light timing is more objective. But the driver's psychological factors are ignored. For example, the investigation on Fuzhou Road intersection shows that the red-light timing ranges from 30 seconds to 130 seconds. Does the red-light timing meet the drivers' expectations or exceed the drivers' waiting limit? When the red-light timing turns into green-light, what kind of drivers' behavior reaction will be? The report of the Department of transportation showed that 50% - 80% of the urban road traffic accidents occurred at the intersection and surrounding, of which 30% occurred in the signal lights transition that during the time of traffic lights turn from green to red or from red to green[2]. The accident causes rely heavily on the drivers' red-light running proneness [3]. While maybe the

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"dilemma zone" is the reason of red-light running proneness behavior [4]. Foreign scholars believe that the formation of dilemma zone is influenced by the driver's expectations (the previous experience of red-light timing to the intersection); predicting the consequences of red-light running and estimating the possibility of red-light braking. Road safety experts believe that setting countdown traffic lights can solve "dilemma zone" to improve safety and traffic efficiency. Although there are some disputes of theoretical and practical management in the green-light countdown signal setting, in the study of Red-light countdown setting, most scholars and managers consider that the setting of Red-light countdown can help drivers in the following aspects :1) predicting the green-light brighting time in advance to reduce the launch losing time in time and improve the intersections efficiency; 2) perceiving the remaining time of red-light signal to adjust the anxiety of waiting the red-light timing. The domestic scholars Qian Hongbo found from the on-site investigation that compared to the intersection unsetting red-light countdown, in the red-light countdown conditions, the average green early losing time of vehicle through the intersection save 1.5 seconds [5].

According to the author 's observation in Fuzhou road intersection, finding that it's common of setting red-light countdown, but red-light timing ranges from 30 seconds to 130 seconds. If the red-light timing meets the demand of road traffic flow, is it also consistent with the driver waiting psychology Exploring the root causes of waiting psychology, from psychological point, which find that waiting make people to bear the economic and psychological costs, experience pressure and lack control feeling of waiting. The less of the control feeling, people's sense of security is lower and easier to cause panic and anxiety emotions [6]. The researchers also find that the red-light timing too long can make the driver anxious and lead to change of driving behavior, increasing the traffic accident rate[5][6]. Foreign traffic psychologist raised that the red-light timing too long can make the driver anxiety to impact motor vehicle start-up time, which increases the unnecessary dead time and reduces the rate of intersection flow, may cause more traffic accidents [3]. In view of the domestic and foreign literature, the study puts forward the following views: the long red-light timing can make the driver anxious. When the red-light turns into green-light, drivers' reaction of starting vehicle is changed, influencing the road intersection traffic capacity. The study assumes that there is a limit of drivers' red-light timing, when the red-light timing exceeds the limit, the reaction of driver noting the green-light slows down. Studying to apply the cognitive psychology experimental paradigm, simulate the red-light timing in the computer, then bring the green-light, test the reaction of the keys when the green-light lights.

1. Research method

1.1. Experimental subject

Recruit30 students with driving experience in Fuzhou University (driving skills self-assessment report score 3 or more points, where five divided into full marks), Men and women in equal.

1.2. Experimental materials

One computer (fitted E-prime software); sixty traffic scene graphs (situations of Fuzhou traffic, strict screening); one red-traffic light picture and one green-traffic light picture.

1.3. Experimental design

The experiment adopts single factor design with the rendering time of red-traffic light as an independent variable. There are five levels: 40s、60s、80s、100s、120s (According to the acquisition of Fuzhou red-light timing of the five most common to determine the average level); the dependent variable is the reaction time of pressing the button when subjects see the green-light.

1.4. Experimental procedure

Laboratory's temperature is 25 degrees; subjects completed the experiment on computer E-prime software.

Firstly inform the subjects that it is a simulated driving experiment instruction is that "The experiment includes three parts: simple reaction, practice experiment, formal experiment. First part, the experiment will present green-light images, please press "P" key immediately when you see the green-light pictures to represent

driving forward." Present five green-light traffic images to the subjects (one for each time), pictures are interval with white screen, white screen's rendering time randomly set at 1-5 seconds. It demands that all the subjects press "P" key immediately when they see the green-light pictures, then measure and record the baseline level of the subjects' reaction.

The second part is practice experiment, presenting a series of traffic pictures, then presenting a red-light picture lasting 30 seconds, finally present green-light picture. Make the subjects press "P" key immediately when they see the green-light pictures. Then they get familiar with the experimental procedure.

The third part is formal experiment. Red-traffic lights presenting time are five independent variable levels (40s、60s、80s、100s、120s). Each level repeated 3 times, a total of 15 experiments. Each group are randomly presented firstly, two seconds of each, that each group will be presented 60 seconds road images the purpose is to simulate the driver is driving on the road and to give the driver some driving time after each pressing the key to avoid driver are always waiting for a red-light, in order to eliminate the superimposed effect of the different red signal light rendering). Instruction of formal experiment is that "presenting a series of traffic pictures for you firstly, then presenting a certain timing red-traffic light picture, finally please press "P" key immediately when you see the green-light pictures to represent driving forward."

The reaction time of the experiment results are automatically recorded by the computer.

1.5. Data Processing

After the experiment, a total of 30 data, men and women were 15 each. Remove all subjects' five simple reaction time, eliminate the first two times that inadequately prepared, then add the remaining three simple reaction time to get the average reaction time.

If the simple reaction time compared with the average reaction time is lower than three standard deviations, then the simple reaction time are considered to meet the requirement of experiment data. The results showed that all the subjects meet the requirements.

Analysis of original data, eliminate two data that fluctuate heavily, finally come to the average reaction time of each level. After the initial treatment, we get a total of 28 valid data.

2. result

2.1. Data analysis

Table 1. Within-subject effect result

factor	spuariance	df	square	F	Sig.
red-light timing （millsecond）	870282.007	4	217570.502	.699	.594

The table 1 showed that when the red-traffic light presenting time are 40s, 60s, 80s, 100s, 120s, the subject reaction time doesn't exist significant differences in the statistical level (p=.594>005). There are no significant differences of the subject reaction time in the five red-light timing.

Researcher analyses all the subject reaction time of each level red-traffic light in chart. Make use of SPSS to get all the subject average reaction time in each dimension red-light timing and draw the line diagram. The results are as follows:

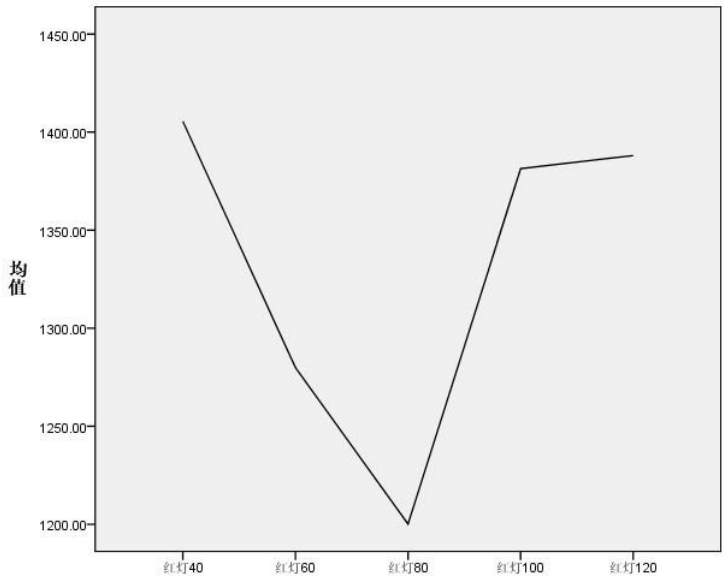

Fig.1. the relationship between reaction time and red light timing

The figure 1 showed that when the red-traffic light presenting time are 40s, 60s, 80s, 100s, 120s, the subject average reaction time are 1405s, 1280s, 1200s, 1381s, 1388s. The red-traffic light presenting time range from 40s to 80s, then the subject average reaction time appeared a downward trend, and there is a minimum in the 80s. When the red-traffic light presenting time is 100s, the subject average reaction time appeared an uptrend. It is a maximum in the 40s.

Researchers make a multiple comparison with the subject average reaction time under the five dimension red-light timing, as the table 2. The figure 1 showed that the significant level is the highest (p=0.143) in the test of red-light 40s with red-light 80s, close to the edge of the significant (p = 0.1), and then the rest of the test results are not significant.

Table 2: paired sample test

Partnership source	standard deviation （millisecond）	t	df	Sig.
1 red-light 40- red-light 60	806.92	.823	27	.417
2 red-light 40- red-light 80	719.63	1.51	27	.143
3 red-light 40- red-light 100	812.00	.157	27	.876
4 red-light 40- red-light 120	591.26	.156	27	.877
5 red-light 60- red-light 80	656.55	.643	27	.526
6 red-light 60- red-light 100	858.58	-.625	27	.537
7 red-light 60- red-light 120	902.95	-.634	27	.532
8 red-light 80- red-light 100	836.00	-1.14	27	.261
9 red-light 80- red-light 120	892.70	-1.11	27	.275
10red-light 100- red-light 120	752.17	-0.47	27	.963

3. Discuss

The experiment uses the cognitive psychology of the reaction time research paradigm, to explore the impact of the red-light timing to the driver. By setting a group of different red-light timing duration, take down the reaction time that experimenter use since saw the green-light on, compared if the different that the impact of different red light time to the driver's reaction is significant. Finding that when the in red waiting time is 80 seconds, the experimenter's average reaction time is the fastest, from 40 seconds to 60 seconds, then to 80 seconds the average reaction appeared downward trend, then appears a characteristics that 80 seconds' reaction is the fastest, by the statistical test, found that it is close to the edge of a significant level (P = 0.1) in 40 seconds and 80 seconds of reaction, but in the reaction time of 100 seconds and 120 seconds are in the rise.

The results show a certain consistency with the experimental expectations assumption, both found that the limit time of the driver wait for the red light, about 80 seconds. This is consistent with a foreign conclusion that traffic signal waiting time exists a limit value, such as the German waiting limit value is 60 seconds, and the British waiting limit value is 45 seconds. For this study, a inference can be drawn: continue increasing the red light waiting times, maybe cannot able to reduce traffic accidents, but will inversely increase the probability of traffic accidents' happen. In the 5 kinds of red light waiting time, the reaction time is the shortest when it's 80 seconds, indicated that the driver may in a long waiting limit state after waiting for 80secons for the red light, the thought that expectation the green light appear caused the rapid response when green light on, therefore the probability of run the red become higher, so as the probability of the traffic accidents.

In this study, there are some limitations. First is the driver groups, college students, although there is a certain driving experience amount of them, but they lack in the proficiency of driving and road, therefore, use the data obtained by the student groups with a certain one-sidedness. Second， the pictures driving simulation used is the pictures of road traffic， control impact of a variety of complex variable realistic road environment, caused the limitations of the study results. Third, the study measured the simple green light cognitive reaction after the student driver to wait for a series of different red light, in the strict sense, it's a measurement of simple reaction time when it's in different road environment. Since under real road conditions, driver response should include a simple reaction and driving motor response. There's a lot of factors that could affect the driver's action, including the performance of the motor vehicle, the driver's personality, as well as the driver's driving proficiency, etc., so the experiment did not measure movement reaction time. The experimental was only one to explore the experimental design， in the future， experiments should be carried out to measure the reaction of the driver in a real road condition, thus validating the accuracy that limits red light time is 80 seconds which was obtained by this experiment.

References

Zhai C.(2006). How much is people's patience of the red-traffic light [J]. Safety and Health, (12): 42-43.

Liu X., Duan, H.(1997). Plane intersection traffic safety evaluation method [J]. Journal of Human Ergonomics, 3 (1) : 49-53

Bell M.C, Galatioto, F, Giuffre, T, Tesoriere, G. (2012). Novel application of red-light runner proneness theory within traffic microsimulation to an actual signal junction[J]. Accident Analysis and prevention, 46 :26-36.

Allos, A.E., Al Haidithi, M.I. (1992) Driver behavior during onset of amber at signalized junctions[J]. Traffic Engineering and Control, 33 (5), 312－317.

Qian, H. (2011). Influence of Red Signal Countdown on Traffic Safety & Efficiency.Journal of Transport Information and Safety, 29（3）：65-68.

Ren, S.,Ji, J (2010). Feasibility Analysis on Safety Measures for Eliminating the Psychological Anxiety of "Red Light Waiting" . Transport Standardization, 24：133-136.