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Analysis of the Influence of Pedestrians' eye Contact on Drivers' Comfort Boundary during the Crossing Conflict

Zeheng Ren[a],Xiaobei Jiang[a*],Wuhong Wang[a] *

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[a]Department of Transportation Engineering, Beijing Institute of Technology, Beijing 100081

Abstract

More and more people, especially young people, use their cellphones or earphones while crossing roads. Many research have confirmed the power of eye contact in normal life, in this study, we want to figure out how pedestrians' stare influence on drivers' comfort boundary. The comfort boundary can be observed form the deceleration of cars and it also varies depends on various reasons. We set the drivers' gender and stare attempt as two variations for this study and measure the change of the cars' speed as results. Confederates are asked to stand by the side of the road without crossing to ensure their safety and tried to either make eye contact with the coming driver or just look above the car. It is found that the eye contact with driver can significantly affect the speed regardless of the confederates' and the drivers' gender. The results emphasize the importance of focus when crossing roads and warn the pedestrians not playing to ensure their own safety.

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Keywords: Eye contact; comfort boundary; time to collision (TTC); deceleration process.

1. Introduction

With development of economy and improvement of life quality, cars have become ordinary consumer items in common life. The car ownership is above one hundred and fifty million and the drivers are about 3 million till the end of 2014. Although the overall trend of traffic safety is getting better in China, nearly 23,000 pedestrians died in car accidents every year and account for 26% of total traffic accident casualties. [1] Not only in China, but also in

* Corresponding author. Tel.:+86 10 68915579.
E-mail address: jiangxiaobei@bit.edu.cn; wangwuhong@bit.edu.cn

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other developed countries, such as France, about 15% (489)of road victims are pedestrians [2].According to the Global road safety report from WHO, there are more than one million people died in traffic accident. The traffic accident has been the eighth leading cause of death and also the main death cause for 19-25 years young people. It is also predicted that the traffic accident will be the fifth leading cause of death by 2030. According to the statistics published by The Transportation Bureau of China, since the number of traffic accident peaked in 2002, the accident statistics index decline year by year. It shows that the countermeasures we took in the past decade have effectively reduce the rate of traffic accidents.

Modern traffic synthesize the interaction relationship between road users, vehicles, roads and environment as a whole. The causation of traffic accident can be various, like visual characteristic, psychographic traits, driving status, number of lanes, weather conditions, width of lanes, quality of traffic politeness and traffic regulations. For example, the smartphones have been widely used especially among young people and people can hardly live a normal life without a smartphone. Using a cellphone while walking even crossing a road is very common but seriously dangerous. Therefore, we can divided the causation into five parts:

- Road users: over speed, distraction or fatigue, false operation, pedestrian and others.
- Vehicles: brake system, steer system, drive system and electric control system.
- Roads: pavement, number of lanes, width of lanes, width of road shoulder, highway alignment and sight distance.
- Environment: traffic condition, geographical condition, traffic model, weather condition, and intersections.
- Operation management: management mechanism, management rules and management personnel.

Eye contact is the most-used method we used to express our emotion. Making an eye contact can tell someone you pay attention to him and make the conversation more harmonious. Many studies have been conducted to prove the eye contact play a vital role in our daily communication. Liu lijuan [3] focus on the functions of eye contact in communication, different information conveyed by eye contact on the basis of different cultures and the importance of understanding and respecting the rituals of eye contact in cross- cultural communication. Valentine [4] proved that we are more likely to help someone with his arm in a sling if he make an eye contact with the confederates to pick up the coins he has just dropped. Steven [5] pointed out that an increase in the amount of eye contact generated by a speaker significantly increased the speaker's credibility in terms of qualification and honesty factors. Snyder [6] found it is more likely for drivers to stop for a hitchhiker when the hitchhiker look straightly into the driver’s eyes. Kleinke [7] indicated that gaze would lead to increased compliance with a legitimate request and decreased compliance with an illegitimate request such as asking dime for a phone call. Goldman [8] proved that eye contact make confederate more willing to help pick up the folders he has just dropped.

The comfort boundary implies the boundary of comfort zone in which the driver have sufficient time and distance to stop before collision, i.e. the boundary is the threshold of distance that the driver start to feel uncomfortable. Comfort boundary can be measured through the decelerating operation of the cars in our real life. Nils [9] used TTC(time to collision) to define the comfort boundary and find out that the TTC is independent of driving speed, trial order and volunteer age, but significantly between driving speeds. Then, Nils [10] conducted an experiment and find the pedestrian speed have a statistically significant influence on brake onset. This relationship can be used to differentiate between desired and undesired system activation in the design of an ‘‘unjustified system response’’ test in the assessment of pedestrian safety systems. Montgomery [11] indicated that there are clear statistical differences in TTC at braking between different genders and ages, on average, women braked at a TTC 1.3 s higher than men.

2. Method.

2.1 Field Study Site

The experiment was conducted at a minor arterial road in Beijing. The road has a 40km/h limitation of speed and it is bi-directional two lanes. The width of the lanes and the sidewalks is 3.5 meters and 2.4 meters, respectively. The experiment started from 1 to 5 p.m. on sunny days. A 100m road segment without side parking is selected as the field study site, and the traffic volume is about 700 cars per hour.

2.2 Sample Description

The variation we set in this experiment is the driver gender and stare attempt. The experiment use one male student in normal dressing as confederates and record 1827 male drivers and 1173 female drivers as targets. The confederates were told to try to make eye contact with the coming driver or just look above the coming car as the second variation.

2.3 Experimental Procedures

As the speed limitation is 40km/h and the slowest speed observed is above 30km/h, so the marks are placed every five meters in a 70 meters segment ahead of the confederates to record the passing time of the cars between each marks. In order to keep the data natural, the speed change process is observed in our real life without using any electric equipment on the cars to influence the drivers or using a simulator.

3000 drivers (60% males and 40% females) were choosing randomly as subjects of this experiment. Two test events were then conducted in random order. The confederates were told to stand by the side of the road to wait for the approaching vehicle and tried to make eye contact with the driver of the approaching vehicle until the car pass by or just looked above the car avoiding eye contact randomly but fifty-fifty in total. The confederates just stood by the side without crossing to ensure their safety and were asked to conduct 10 times experiments and then changed the confederate.

The time that the cars used to pass each marks were recorded to calculate the speed change process. After the cars passing by, the confederates recorded the driver gender and the stare attempt.

3. Data Analysis and Results

3000 subject vehicle speed were recorded, and we classified the vehicles by the distance– from the onset of deceleration. 2990 samples were selected without consideration of the stopping vehicles (3 stopping vehicles with eye contact and 7stopping vehicles without eye contact) during the observation periods and the sample numbers by categories under different situations is shown in table 3.1 and 3.2.

Table 1.Without eye contact

Segment(m)	Male Number	Percentage	Female Number	Percentage
45~50	8	0.9%	66	11.3%
40~45	10	1.1%	65	11.1%
35~40	25	2.7%	69	11.8%
30~35	39	4.3%	92	15.7%
25~30	249	27.5%	130	22.2%
20~25	230	25.2%	138	23.7%
15~20	225	24.6%	20	3.4%
10~15	126	13.8%	5	0.9%
Total	914		586	

According to the results, the deceleration process differs from different genders. Male starting distance of deceleration is shorter than female under two test events, but the influence of eye contact act more apparently for men than women. Nearly 50% of men prolong their stopping distance by 5 meters while the percentage of women is about 30%. In total, eye contact has a crucial influence on the deceleration starting distance. The velocity change process under two test events are depicted in figure 3.1 and 3.2 and the average velocity change process of different driver genders are depicted in figure 3.3 and 3.4.

Table 2 With eye contact

Segment(m)	Male Number	Percentage	Female Number	Percentage
45~50	18	1.9%	71	12.9%
40~45	38	4.0%	120	21.8%
35~40	86	9.1%	134	24.3%
30~35	170	17.9%	90	16.3%
25~30	250	26.3%	73	13.2%
20~25	175	18.4%	50	9.1%
15~20	120	12.6%	10	1.8%
10~15	92	9.7%	3	0.5%
Total	949		551	

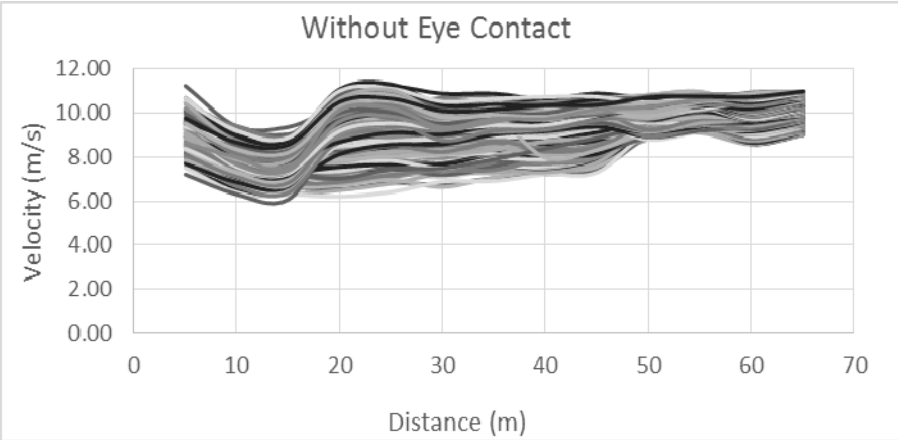

Figure 1 velocity change process without eye contact

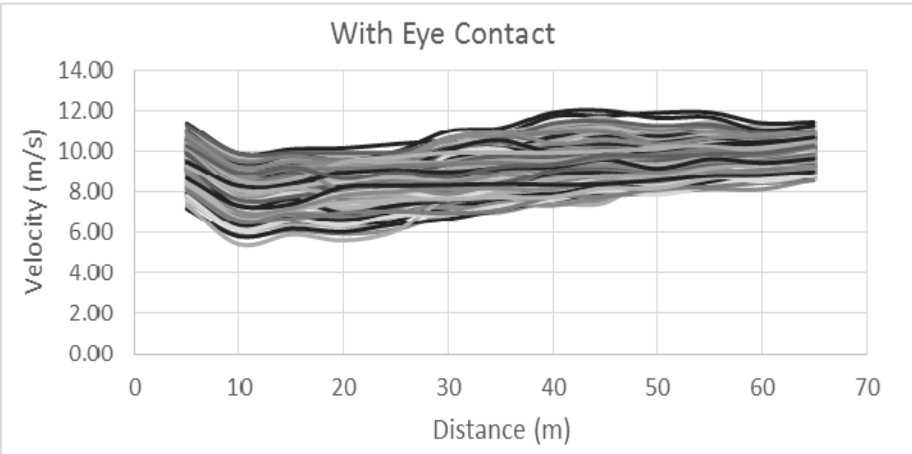

Figure 2 velocity change process with eye contact

Figure 3 average velocity change process without eye contact

Figure 4 average velocity change process with eye contact

As depicted in the figures, eye contact apparently decrease the speed of cars especially for male drivers and also make the deceleration process smoother. Then the empirical cumulative distribution was calculated for two conditions and depicted as figure 3.5.

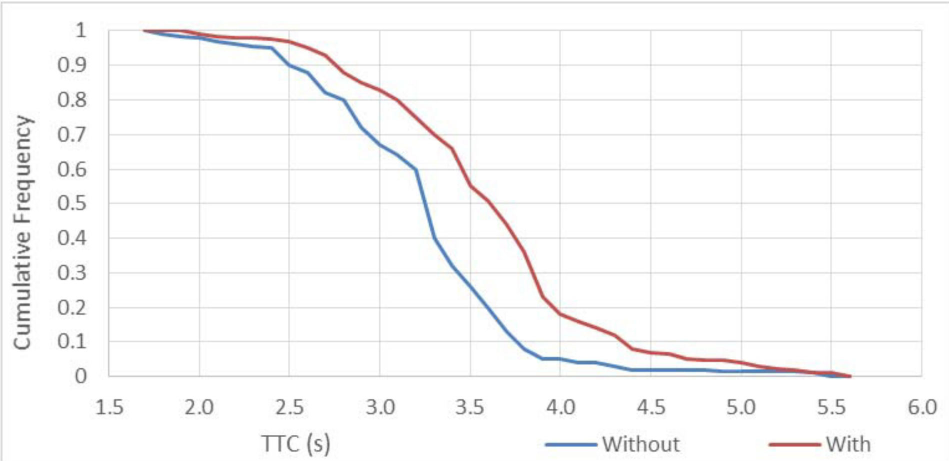

Figure 5 empirical cumulative distribution (ECD)

The TTC with eye contact is ranging from 1.76 to 5.49s and the median is 3.24s while the TTC without eye contact is ranging from 2.06 to 5.58s and the median is 3.48s. The median of TTC has increased with eye contact by 0.24s, and if the approaching car travels at 9m/s, the stopping distance for this driver will be extended by 2 meters which can avoid the hazards.

The Influence of eye contact is analyzed by using two-sided t-tests (α=0.05). We set the null hypothesis as there is no difference of TTC between two test events:

H0: $\mu0= \mu1$

And the alternative hypothesis is that they are different:

H1: $\mu0\neq\mu1$

We use SPSS to run the test and the result is shown below.

Table 3.3 T-test results

		Test		t-test for Equality of Means					
		F	Sig.	t	Sig.	(2-tailed)	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
TTC	Equal Variances assumed	.011	.917	-.104	.0217		0.24233	8.73719	9.71400
	Equal Variances not assumed			-.104	.0135		0.24233	8.82163	9.62543

The significant level of Test under Equal Variances assumed is 0.917 which means the assumption is right. And the Sig. (2-tailed) is smaller than 0.05 which indicates that we should deny the null hypothesis and accept the alternative hypothesis. The result shows that eye contact has a great influence on TTC.

4. Drivers' comfort boundaries based on eye

TTC is a surrogate safety measure for unjustified system response, and it is also the most widely used in traffic research. TTC is also suitable to be used to define the comfort boundary of drivers because it is rarely affected by other conditions. TTC is determined by the speed and distance at the point where the cars decide to decelerate. The speed we measured ranged from 5.8 m/s to 11.5 m/s without eye contact and it changes to the range from 5.7m/s to 12.2m/s with eye contact. Although the range of speed doesn't change a lot, the trend of the variation is much smoother which means the amount of drastic brake is decreased. On the other hand, the average distance that the drivers start to decelerate is prolonged nearly by 5meters which gives the drivers more time to react.

The deceleration process differs from different genders. Male starting distance of deceleration is shorter than female under two test events, but the influence of eye contact act more apparently for men than women. Nearly 50% of men prolong their stopping distance by 5 meters while the percentage of women is about 30%. In total, eye contact has a crucial influence on the deceleration starting distance. As depicted in the figures, eye contact apparently decrease the speed of cars especially for male drivers and also make the deceleration process smoother.

Figure 3.5 compare the TTC of eye contact event with non-eye contact. The upper trend of two events is the same but the upper tail of eye contact event is more obvious than non-eye contact event which shows the benefit of eye contact. We can divide the deceleration process into three conditions:

- Drivers notice the pedestrian and think the pedestrian is going to cross the road, so they start to decelerate at a long distance.
- Drivers notice the pedestrian but choose to brake in a short distance, because they think the pedestrian is not going to cross.
- Drivers notice the pedestrian in a short distance and take a fierce brake.

The results confirm that most of the drivers decelerate to pass by the pedestrians if he or she make eye contact with both male and female drivers. We increase the number of the first condition by decrease the number of the second and third conditions because eye contact is the most efficient nonverbal way to communicate. The function of eye contact is a lot, and the most representative function is feedback. Eye contact can be perceived as a signal of stop or attention and in addition, eye contact can also initiate a positive reaction between people which can explain the result of our research. In China, the traffic environment is not cheerful and pedestrian is dangerous on the road especially crossing the road. Our research prove the powerful effect of eye contact with naturalistic statistics and inform the public that making eye contact with drivers while crossing the road can improve your safety.

5. Conclusion.

In this study, we use time to collision (TTC) to represent the comfort boundary of drivers. The drivers' gender and eye contact are set as variations of this research. The results show that the median of TTC varies from 3.24s to 3.48s if the confederate make eye contact with drivers and the influence of eye contact is greater for male drivers to female drivers. Eye contact not only increase the TTC to make drivers have more time to react, but also make the deceleration process smoother which decrease the amount of drastic brake to improve pedestrians' safety.

The results found in this study have some practical meanings. Time to collision is a suitable variation to define the comfort boundary of drivers and the median value for two different conditions can be used to modify the threshold value of Advanced Driving Assistant Systems (ADASs). The most important conclusion we get is that eye contact has a great impact on drivers' behavior which can significantly increase the TTC to protect the pedestrians. The conclusion can also enhance the awareness of public traffic safety effectively with realistic and natural data.

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