CHARACTERISTICS AND INSECURITY OF VIOLATION BEHAVIOR OF NON-MOTORISTS AT SIGNALIZED INTERSECTIONS IN CHINA

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ABSTRACT

Aimed at prevalent violations of non-motorists at urban intersections in China, this paper intends to clarify the characteristics and insecurity of violations of non-motorists at signal intersections through questionnaire and video recording, which may serve as the basis for non-motor vehicle management with the purpose of improving the traffic order and enhancing the safety degree of signal intersections. The study finds that majority personal attributes such as academic degree and income contribute little to non-motorists violations; while electrical bicyclists have relatively higher frequency of violations compared with bicyclists; violation rate and types of violation behavior of three types of surveyed intersections are markedly different. It is also found that conflicting number, conflicting rate and violation rate are positively correlated. Furthermore, running red lights, traveling in the wrong direction and rushing forward at the end of green light are most dangerous among traffic violations.

Keywords: traffic violation behavior, traffic safety, non-motorists, signal intersections.

INTRODUCTION

Compared with developed countries, China differentiates itself with mixed traffic of motors, non-motors and pedestrians. According to *Law of the People's Republic of China on the Road and Traffic Safety*, non-motor vehicle powered by human or animal can run on roads, including the vehicles such as motor wheel chairs for the disabled and electrical bicycles which have power drive but maximum design speed, unladen weight and external dimension have to meet national standards. Therefore, bicycles and electrical bicycles are finally set as the research objects of the paper.

Widely known as the kingdom of bicycles, China ranks the first in terms of production capacity, bicycles' quantity and usage of bicycles. Recent years, electrical bicycles among the public became increasingly popular as they are light, flexible, cheap, energy-conserving and fast. Therefore, they often mix with motor vehicles on urban roads, thus leading to one of the major problems of traffic system. According to the statistics of annual report for traffic accidents from traffic administration of the Ministry of Public Security, electrical bicycles result in death toll up to 51.6 percent in 2007 compared with 2006.

As the nodal points of urban road network, intersections collect various traffic flows from different directions. In order to strive for limited resources in time and space, non-motor vehicles, motor vehicles and pedestrians easily collide with each other, thus resulting in traffic jam even accidents. Meanwhile, as non-motor vehicle management is nonstandard in China, non-motorists maintain a low sense of traffic law and penalties are not easy to implement, traffic in intersections is likely to fall into disorder.

Presently, a number of scholars in China and abroad devote themselves into the researches on non-motor vehicle behavior at intersections: Liu (2005) mainly investigates the centralizing behavior and decentralizing behavior of bicycles at intersections.

Su et al. (2007) mainly studies about the road user's behavior when crossing urban intersections, including the confliction patterns among motors, non-motors and pedestrians, the influence on motor vehicles of non-motors' and pedestrians' violating behavior; Huang and Wu (2004) focused on the cyclists' behavior at signalized intersections, including the crossing speeds, crossing gap/lag acceptance behavior, and group-riding behavior.

On the other hand, to the conflicts produced by non-motor vehicles, Wang and Nihan (2004) modeled bicycle-motor vehicle crashes at 115 signalized intersections in Tokyo, Japan. They classified crashes as BMV-1 (collisions between bicycles and through motor vehicles), BMV-2 (collisions between bicycles and left-turning motor vehicles), and BMV-3 (collisions between bicycles and right-turning motor vehicles). The Pedestrian and Bicycle Crash Analysis Tool may be used to develop and analyze a database containing the crash types and other details of crashes between motor vehicles and bicyclists or pedestrians. The user can then access the countermeasure module to see what engineering, education, and enforcement treatments are appropriate; The research "pedestrian and bicyclist intersection safety indices" involved collecting data on pedestrian and bicycle crashes, conflicts, avoidance maneuvers, and subjective ratings of intersection video clips by pedestrian and bicycle experts. Based on the mass data, it determined indicative variables in the bicycle safety models (for through, right-turn, and left-turn bike movements), including various combinations of: presence of bicycle lane, main and cross

street traffic volumes, number of through lanes, presence of on-street parking, main street speed limit, presence of traffic signal, number of turn lanes.
Meanwhile, a small number of Chinese scholars concentrate their attentions on the violation behavior of non-motor vehicles. Based on the researches on the cost of violation of law for non-motorists and investigation into different groups in Nanjing, it is found that violation of traffic law has become universal behavior among Chinese people, rather than the behavior of a handful of people; different groups only differentiate themselves in violation modes and there are no differences in quantity and quality; Zhao (2006) analyzed red light running behavior of non-motors at signalized intersections as well as its influence on time and speed when motor vehicles pass the intersections; after roadside investigation, it is found that running red lights, crossing motor lane illegally and traveling in the wrong direction are most easily to lead to accidents for non-motor vehicle.

Therefore, the objective of the paper is to highlight violation behavior characteristics of non-motors at intersections, and disclose its universality and gravity as well as the insecurity of violation behavior of non-motorists, which may serve as the basis for non-motor vehicle management and traffic order maintaining at intersections.

RESEARCH METHODOLOGY

Questionnaire

The survey was conducted on the internet and each respondent was required to fill the following information: age, gender, income and academic, etc.

The survey was conducted in January 2010. 1162 questionnaires in total are withdrawn, including 972 valid questionnaires, with the valid recovery rate of 83.2 percent. Bicycle questionnaires and electrical bicycle questionnaires withdrawn are respectively 647 and 515, with valid questionnaires respectively 556 and 416.

7 kinds of violation behaviors are listed in the questionnaire: running on the motor lane (occupying), drunk driving bicycles/drunk driving electrical bicycles (drunk driving), traveling in the wrong direction (reverse traveling), driving at high speed (overspeeding), disobeying traffic signals (signal violation) , traveling too fast around the corner (fast turning) and crossing the road by bicycle suddenly (jay walk).

Respondents are required to impart the frequency of occurrence of the above-said behaviors in the form of 5 degrees “often, sometimes, average, seldom, never” with 1-5 points for different degrees, and higher points indicate lower frequency of violation behaviors and higher security degree.

Survey data is analyzed by SPSS 17.0 and correlation between violations and personal attributes is explored. Seven detailed violation behaviors and overall violation difference are analyzed with ANOVA for individuals of different ages, genders, academic status and incomes. It is to dig out the influence of these personal attributes on non-motorists.

Video Recording Survey

First, it is to choose the intersections which shall have different phasing, size, degree of intersecting roads and traffic volume in order to know how non-motorists behave at signalized intersections of different types. Through field investigation of a number of intersections, it finally determines 3 standard intersections. Xuefu Road-Chengxian Street intersection is an A-type intersection, which is adjacent to Southeast University with light traffic volume, small, providing with simple signalizing system, and Chengxian Street is for mixed traffic of motor and non-motor; Jiefang Nanlu-Liuting Street intersection is a B-type intersection, which has medium scale and medium traffic volume with left-turning phase; Hongwu Road-Huaihai Road intersection is a C-type intersection, located at the commercial center of Nanjing City, which is surrounded by a plurality of large-scale shopping malls, big, has complicated signalizing system and heavy traffic volume and pedestrian volume.

Meanwhile, it is to choose intersections which have higher degree of mixed traffic without special interference characteristics. Good shooting places are also important to ensure the data collecting. Shooting may be arranged in fine weather, and bad weather such as rain, snow, hail stone and strong wind must be avoided to ensure the normal psychology and traffic behavior of non-motorists.

TABLE 1 Intersection Video Recording

Intersection type	Intersection	Intersection scale	Signal phase	Intersecting road degree	Lane number of intersecting roads
A	Xuefu Road-Chengxian Street	Small	2	Sub-branch	2-2
B	Jiefang Nanlu-Liuting Street	Medium	4	Main-sub	4-3
C	Hongwu Road-Huaihai Road	Large	6	Main-main	4-4

FIGURE 1 Xuefu Road-Chengxian Street

FIGURE 2 Jiefang Nanlu-Liuting Street

FIGURE 3 Hongwu Road-Huaihai Road

Through preliminary investigation, it is found that major violations of non-motorists at intersections include: rushing forward at the end of green light, running red lights, rushing

forward just when the red light switches to green, occupying motor lane, traveling in the wrong direction and parking outside the stop line.

Through processing of video data, it finally obtained the following data: motor vehicle, bicycle and electrical bicycle volume, signal phase, violation behavior data of non-motorists at intersections, number of conflicts at intersections, number of conflicts at intersections caused by violation behavior of non-motorists. 1683 violation cases of non-motor vehicle have been acquired.

Statistical methods and SPSS software are applied in the analysis of relevant data of violations of non-motorists in order to test the relations between violations and traffic volume; meanwhile, Spearman rank Correlation Coefficient is applied in order to test the relations between violations and traffic volume; ANOVA is also applied to test the characteristic value and differentiations of the risk degree of major violation behavior manifested at three types of intersections.

RESULTS

Analysis of Violation of Bicyclists of Different Personal Attributes

Age Differences

Bicycle users questioned are almost 18~55 years old and most bicycle users are centered in group with the age of 18~30. See the following table for different violation behavior of bicycle users of different ages.

Through variance analysis it can be found that there are marked differences between “traveling in the wrong direction” and “traveling too fast around the corner” in terms of ages. From the mean value, it is obvious that bicyclists of different ages vary much in violating traffic laws. (When $\alpha = 0.025$, $F(4,642) \approx 2.85$, namely $F > 2.85$ as well as $p < 0.05$).

Gender Differences

Through variance analysis it can be found that bicyclists of different genders show marked differences in majority detailed and overall violation behavior (when $\alpha = 0.025$, $F(1,642) \approx 5.05$, namely $F > 5.05$ as well as $p < 0.05$); only exhibit few differences in “reverse traveling” and “jay walk”. Namely, bicyclists of different genders vary much in violating traffic laws.

Academic Degree Differences

From table 2 it can be seen that there are not marked differences on all the detailed and overall violation behavior of bicyclists of different academic degrees and all the result values satisfy $F < 3.15$ or $p > 0.05$ (when $\alpha = 0.025$, $F(3,642) \approx 3.15$). It can be seen that there is little difference among bicyclists of different education level in violation behavior.

Income Differences

From table 2 it can be seen that there are no marked differences on all the detailed and overall violation behavior of bicyclists of different incomes and all the result values satisfy $F < 3.15$ or $p > 0.05$ (when $\alpha = 0.025$, $F(3,642) \approx 3.15$). It can be seen that income is not a contributing factor to violation behavior differences of bicyclists.

TABLE 2 Analysis on Violation of Bicyclists of Different Personal Attributes

Violation	Age					*F*	*p*
	Below 18	18-30	31-40	41-50	Above 50		
Occupying	3.50	2.89	2.96	3.21	3.57	1.892	0.110
Drunk driving	4.50	4.11	3.94	4.05	4.52	1.318	0.259
Reverse traveling	3.00	3.15	2.98	3.78	3.70	3.972	0.003
Overspeeding	2.67	3.48	3.45	3.93	3.84	1.593	0.176
Signal violation	3.50	3.59	3.55	3.86	4.11	1.422	0.228
Fast turning	3.50	3.59	3.68	4.33	4.25	4.621	0.001
Jay walk	4.00	3.82	3.86	4.25	4.45	2.429	0.046
Average	3.52	3.52	3.49	3.92	4.06	4.004	0.007

Violation	Gender		*F*	*p*
	Male	Female		
Occupying	2.85	3.18	7.811	0.005
Drunk driving	3.88	4.42	24.905	0
Reverse traveling	3.10	3.29	2.636	0.105
Overspeeding	3.26	3.97	33.967	0
Signal violation	3.51	3.82	8.132	0.005
Fast turning	3.58	3.88	7.846	0.005
Jay walk	3.86	3.94	0.51	0.475
Average	3.43	3.79	18.849	0

Violation	Academic degrees				*F*	*p*
	Middle school or below	Technical secondary school or high school	College or university	Master or above		
Occupying	3.20	3.04	2.96	2.96	0.175	0.913
Drunk driving	4.40	4.27	4.04	4.05	0.880	0.451
Reverse traveling	3.20	3.24	3.18	3.08	0.159	0.924
Overspeeding	4.40	3.70	3.46	3.54	1.944	0.121
Signal violation	3.65	3.61	3.61	3.62	0.003	1.000
Fast turning	4.10	3.70	3.70	3.61	0.486	0.692
Jay walk	4.40	3.96	3.84	4.11	1.550	0.201
Average	3.91	3.65	3.54	3.57	0.728	0.536

Violation	Income (CNY/year)				*F*	*p*
	Below 20000.00	20000.00-50000.00	50000.00-80000.00	Above 80000.00		
Occupying	2.91	3.04	2.93	2.91	0.444	0.722
Drunk driving	4.13	1.12	3.91	3.93	0.828	0.479
Reverse traveling	3.07	3.20	3.28	3.34	0.769	0.511
Overspeeding	3.54	3.59	3.28	3.36	1.249	0.291
Signal violation	3.59	3.63	3.64	3.63	0.705	0.974
Fast turning	3.63	3.72	3.65	4.05	0.912	0.435
Jay walk	3.83	3.85	4.05	4.18	1.254	0.290
Average	3.53	3.16	3.53	3.63	0.268	0.848

Analysis of Violation of Electrical Bicyclists of Different Personal Attributes

Age Differences

Electrical bicycle users questioned are 18~55 years old and most users are centered in group with the age of 26~40. See the following table for different violation behavior of electrical bicycle users of different ages.

Through variance analysis it can be found that electrical bicyclists of different ages exhibit a few differences in majority detailed and overall violation behavior; only show marked differences in "jay walk" (when $\alpha = 0.025$, $F(5,509) \approx 2.50$, namely $F > 2.50$ as well as $p < 0.05$). Namely, there is little difference among electrical bicyclists of different ages in violation behavior.

Gender Differences

Through variance analysis it can be found that there are marked differences in majority detailed and overall violation behavior of electrical bicyclists of different genders (when $\alpha = 0.025$, $F(1,509) \approx 5.08$, namely $F > 5.08$ as well as $p < 0.05$); there are a few differences in "traveling in the wrong direction" and "jay walk". Namely, electrical bicyclists of different genders vary much in violating traffic laws.

Academic Degree Differences

From table 3 it can be seen that there are not marked differences on the detailed and overall violation behavior of electrical bicyclists of different academic degrees and all the result values satisfy $F < 3.18$ or $p > 0.05$ (when $\alpha = 0.025$, $F(3,509) \approx 3.18$). It can be seen that there is little difference among electrical bicyclists of different education level in violation behavior.

Income Differences

From table 3 it can be seen that there are not marked differences on the detailed and overall violation behavior of electrical bicyclists of different incomes and all the result values satisfy $F < 3.18$ or $p > 0.05$ (when $\alpha = 0.025$, $F(3,509) \approx 3.18$). It can be seen that income is not a contributing factor to violation behavior differences of electrical bicyclists.

TABLE 3 Analysis on Violation of Electrical Bicyclists of Different Personal Attributes

Violation	Age						*F*	*p*
	18-25	26-30	31-35	36-40	41-50	Above 50		
Occupying	2.65	2.44	2.46	2.66	2.41	3.00	1.300	0.263
Drunk driving	3.40	3.34	3.41	3.49	2.88	3.63	1.539	0.176
Reverse traveling	2.96	2.71	2.93	3.03	3.00	3.00	1.787	0.114
Overspeeding	2.88	2.75	2.98	3.11	2.88	3.46	2.204	0.074
Signal violation	3.20	3.04	3.13	3.14	3.18	3.36	0.595	0.704
Fast turning	3.10	3.05	3.14	3.37	3.06	3.55	1.504	0.187
Jay walk	3.01	3.11	3.34	3.49	3.12	3.27	2.738	0.019
Average	3.03	2.92	3.06	3.18	2.93	3.32	1.859	0.087

Violation	Gender		*F*	*p*
	Male	Female		
Occupying	2.38	2.74	13.153	0
Drunk driving	3.23	3.63	19.630	0
Reverse traveling	2.87	2.83	0.190	0.663
Overspeeding	2.75	3.15	16.799	0
Signal violation	3.04	3.24	5.120	0.036
Fast turning	3.04	3.25	5.659	0.018
Jay walk	3.16	3.25	1.002	0.318
Average	2.92	3.16	12.163	0.001

Violation	Academic degrees				*F*	*p*
	Middle school or below	Technical secondary school or high school	College or university	Master or above		
Occupying	1.90	2.43	2.54	2.56	1.530	0.206
Drunk driving	3.00	3.34	3.37	3.52	0.849	0.468
Reverse traveling	2.60	3.02	2.85	2.86	0.877	0.453
Overspeeding	2.80	2.89	2.90	2.72	0.304	0.822
Signal violation	2.40	3.09	3.15	2.88	3.018	0.030
Fast turning	3.00	3.17	3.11	3.16	0.154	0.927
Jay walk	3.00	3.21	3.20	3.20	0.184	0.907
Average	2.67	3.02	3.02	2.99	0.954	0.415

Violation	Income(CNY/year)				*F*	*p*
	Below 20000.00	20000.00-50000.00	50000.00- 80000.00	Above 80000.00		
Occupying	2.43	2.52	2.60	2.33	0.742	0.528
Drunk driving	3.34	3.41	3.33	3.33	0.277	0.842
Reverse traveling	2.91	2.85	2.91	3.00	0.461	0.710
Overspeeding	2.79	2.95	2.88	2.78	0.783	0.504
Signal violation	3.16	3.15	3.04	2.89	0.959	0.412
Fast turning	3.13	3.15	3.04	3.04	0.457	0.713
Jay walk	3.18	3.24	3.15	3.04	0.647	0.585
Average	2.99	3.04	2.99	2.92	0.827	0.480

Statistics of Violation Behavior and Violation Rate

Through analyzing the video documents, it is to figure out the volume of non-motor vehicle and number of violation types in the periods. See the following table:

TABLE 4 Intersection Traffic Volume and Statistics of Non-motorist Violation

Intersec-tion type	Phase number	Motor number (veh/10 min)	Non-motor number (veh/10 min)	Total Number (veh/10 min)	Proportion of non-motor	Proportion of electrical bicycle in non-motor	Violation number (times/10 min)	Violation rate
A	2	123	180	303	0.59	0.31	102	0.567

	2	129	173	302	0.57	0.32	81	0.468
	2	132	137	269	0.51	0.40	58	0.423
	2	141	208	349	0.60	0.43	88	0.423
	2	135	183	318	0.58	0.40	72	0.393
	2	146	190	336	0.57	0.34	71	0.374
B	4	710	293	1003	0.29	0.36	96	0.328
	4	635	314	949	0.33	0.36	105	0.334
	4	623	286	909	0.31	0.43	93	0.325
	4	751	211	962	0.22	0.28	56	0.265
	4	716	253	969	0.26	0.30	75	0.296
	4	634	259	893	0.29	0.31	84	0.324
	4	677	243	920	0.26	0.37	82	0.337
	4	646	210	856	0.25	0.39	80	0.381
	4	632	212	844	0.25	0.34	83	0.392
	4	685	189	874	0.22	0.28	62	0.328
	4	586	197	783	0.25	0.22	76	0.386
	4	536	204	740	0.28	0.22	63	0.309
C	6	502	366	868	0.42	0.45	40	0.109
	6	454	402	856	0.47	0.44	40	0.100
	6	450	279	729	0.38	0.42	28	0.100
	6	478	259	737	0.35	0.49	31	0.120
	6	519	319	838	0.38	0.47	50	0.157
	6	494	366	860	0.43	0.45	67	0.183

From the above table, it can be seen that among three types of intersections, A-type intersection has the slightest traffic volume with 2000 vehicles/h (including motor vehicle and non-motor vehicle); non-motor vehicle accounts for the largest proportion with approximately 55 percent and also has highest violation rate. The traffic flow at B-type intersections is about 4000 vehicles/h, which is between the flow values of A-type and C-type. The non-motor proportion at B-type intersections is the smallest, about 25%, and the non-motorists violating rate is less than that at A-type intersections. C-type intersection has the heaviest traffic volume with 5000 vehicles/h; non-motor vehicle accounts for approximately 40 percent and has lowest violation rate.

Analysis of Contributing Factors of Violation Rate

It is to conduct analysis on violation rate of non-motorists at different types of intersections and also to clarify the relations between violation rate of non-motorists and traffic volume of motor vehicle, traffic volume of non-motor vehicle, non-motor vehicle rate and the proportion of bicycle in non-motor vehicle.

TABLE 5 Variance Analysis on Violation Rate of Various Intersections

Intersection type	Mean	Std. Deviation	*F*	*p*
A	0.441	0.069		
B	0.334	0.037	71.579	0
C	0.123	0.034		

There are marked differences in violation rate of three types of intersections. Among them, A-type intersection has the highest violation rate.

TABLE 6 Analysis on Contributing Factors of Violation Rate

Spearman's rho		Principal factor	Other main factors			
		Intersection type	Quantity of motor vehicle	Quantity of total vehicle	Proportion of non-motor vehicle	Proportion of electrical bicycle in non-motor vehicle
Violation rate	Correlation Coefficient	-0.912**	-0.857*	-0.424*	0.235	0.676
	Sig. (2-tailed)	0.000	0.029	0.017	0.654	0.140

*Note: *. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*

Violation rate is negatively correlated with intersection type, motor vehicle volume and total motor vehicle volume, while positively correlated with non-motor vehicle proportion and electrical bicycle proportion in non-motor vehicle. Furthermore, the correlation between violation rate and intersection type is significant.

Analysis of Insecurity of Non-motorist Violation Behavior

As it is impossible to obtain the data of accidents happening at intersections annually, the paper makes an effort by way of rules of conflict to analyze the insecurity of violation behavior of non-motorists.

TABLE 7 Various Violation Behavior

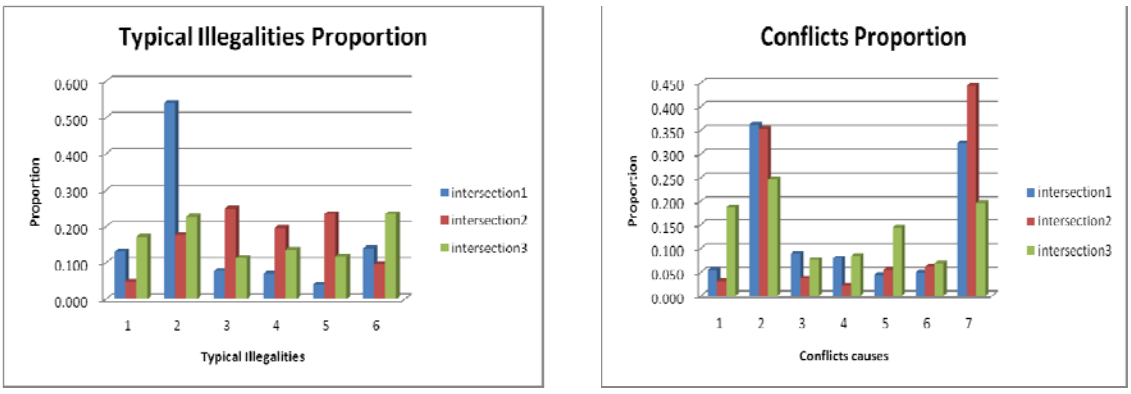
Intersection type	Rushing forward at the end of green light (times/10 min)	Running red lights (times/10 min)	Rushing forward just when red light switches to green (times/10 min)	Occupying motor lane (times/10 min)	Traveling in the wrong direction (times/10 min)	Parking outside the stop line (times/10 min)
A	15	66	5	7	3	6
	12	49	10	5	1	4
	4	27	5	6	6	10
	11	41	9	5	4	18
	10	41	5	5	2	9
	10	31	3	5	3	19
B	10	18	13	23	19	13
	6	21	27	15	26	10
	11	14	7	14	38	9
	0	15	10	9	19	3
	1	15	14	8	31	6
	2	16	11	20	26	9
	3	17	23	17	14	8
	0	9	46	4	14	7

	4	16	31	12	12	8
	6	7	23	15	7	4
	2	10	6	43	7	8
	2	10	27	7	11	6
C	3	6	7	4	8	12
	7	18	5	5	2	3
	6	5	1	4	4	8
	5	7	6	5	2	6
	14	9	5	6	5	11
	9	13	5	11	9	20

TABLE 8 Various Violation Behavior and Mean Value of Conflict

serial number of behavior	1		2		3		4		5		6		7
Intersection type	Rushing forward at the end of green light (times/10 min)		Running red lights (times/10 min)		Rushing forward just when red light switches to green (times/10 min)		Occupying motor lane (times/10 min)		Traveling in the wrong direction (times/10 min)		Parking outside the stop line (times/10 min)		Non-violation conflicts
	V	C	V	C	V	C	V	C	V	C	V	C	
A	10.3	1.8	42.5	12.2	6.2	3.0	5.5	2.7	3.2	1.5	11.0	1.7	10.8
B	3.9	0.8	14.0	9.7	19.8	1.0	15.6	0.6	18.7	1.5	7.6	1.7	12.2
C	7.3	3.7	9.7	4.8	4.8	1.5	5.8	1.7	5.0	2.8	10.0	1.3	3.8

Note: V represents "violation number", and C represents "conflicts incurred".



(a) proportion of typical violation behavior (b) proportion of conflict incurred by various causes

FIGURE 4 Major violation behavior at various intersections and conflict incurred

The above two figures demonstrate violation rate and conflict rate triggered by violation of three types of intersections. Running red lights is the leading contributing factor to the accidents at intersections. Non-violation conflict refers to conflict caused by vehicle which travel in light of traffic law in terms of whether time or space against the current phasing system; non-violation conflict is also a major contributing factor to the accidents at intersections; however, it can be reduced by reasonable signal design and intersection channelization. From the above table it can

be seen that non-violation conflict rate at B-type intersection is the highest among the three intersections.

TABLE 9 Description of Conflicts at Various Intersections

	Intersection type	Mean	Std. Deviation
Violation conflict number	A	22.833	3.061
	B	15.250	4.393
	C	15.833	3.189
Total conflict number	A	33.667	3.983
	B	27.418	3.988
	C	19.667	3.724
Proportion of violation conflict	A	0.679	0.063
	B	0.547	0.099
	C	0.804	0.058
Conflict rate	A	0.218	0.024
	B	0.070	0.008
	C	0.050	0.012

It can be seen from the above form that A-type intersection has the highest conflict rate with most violation conflicts and total conflicts. Violation conflict rate of three types of intersections are all above 50 percent, among which violation conflict accounts for 80 percent at C-type intersection.

TABLE 10 Correlation Analysis of Conflict and Violation Rate

Spearman's rho		Violation conflict number	Total conflict number	Conflict rate
Violation rate	Correlation Coefficient	0.512*	0.713**	0.762**
	Sig. (2-tailed)	0.011	0	0

*Note: *. Correlation is significant at the 0.05 level.*
***. Correlation is significant at the 0.01 level.*

Violation conflict number, total conflict number and conflict rate at intersections are positively correlated with violation rate, namely, the higher violation rate, the more conflicts at intersections and the higher conflict rate.

The paper defines the conflict number/violation number caused by some violation behavior as the risk degree with an aim to analyzing the insecurity of violation behavior of non-motorists at signalized intersections.

TABLE 11 Description of Risk Degree of Major Violation Behavior

serial number of behavior	Risk degree of violation behavior	Intersection type	Mean	Std. Deviation	*F*	*p*
1	Rushing forward at the end of green light	A	0.216	0.159	5.978	0.010
		B	0.203	0.175		
		C	0.588	0.347		
		Total	0.312	0.279		
2	Running red lights	A	0.300	0.070	3.532	0.048
		B	0.768	0.443		
		C	0.603	0.289		
		Total	0.610	0.389		
3	Rushing forward just before the red light switches to green	A	0.554	0.316	9.618	0.001
		B	0.059	0.073		
		C	0.390	0.359		
		Total	0.266	0.316		
4	Occupying motor lane	A	0.479	0.156	25.941	0.000
		B	0.037	0.046		
		C	0.254	0.189		
		Total	0.202	0.221		
5	Traveling in the wrong direction	A	0.583	0.468	4.621	0.022
		B	0.116	0.120		
		C	0.818	0.869		
		Total	0.409	0.561		
6	Parking outside the stop line	A	0.178	0.203	0.040	0.961
		B	0.198	0.139		
		C	0.183	0.138		
		Total	0.189	0.150		

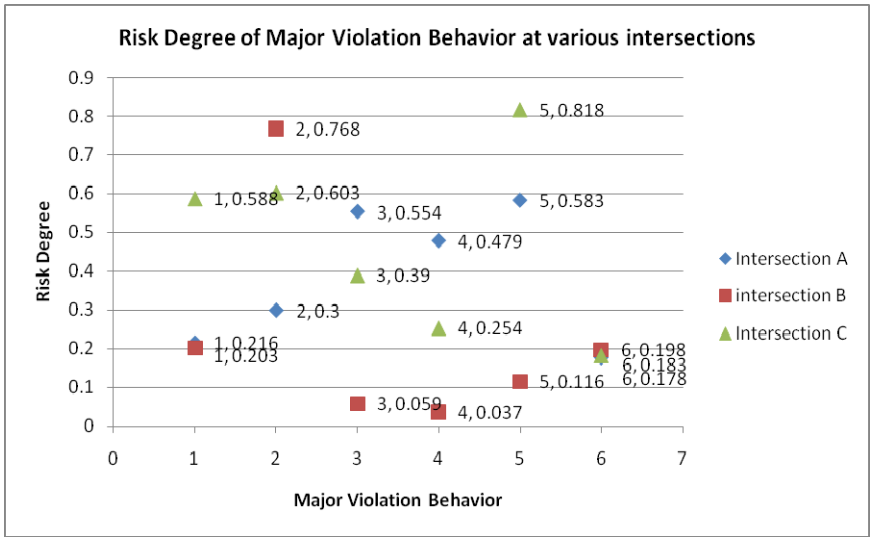


FIGURE 5 Risk Degree of Major Violation Behavior at various intersections

From the above analysis, it can be seen that “rushing forward just before the red light switches to green”, “occupying motor lane” and “traveling in the wrong direction” are dangerous violation behavior with similar risk degrees higher than 0.5 for A-type intersections. Whatever, risk degree of “running red lights” is far higher than other behavior for B-type intersections. “Rushing forward at the end of green light” and “running red lights”, particularly “traveling in the wrong direction” are dangerous violation behavior for C-type intersections. Generally speaking, “running red lights”, “traveling in the wrong direction” and “rushing forward at the end of green light” are exposed to risk of the highest degree.

DISCUSSIONS

Non-motorist Violation is Universal Phenomenon in China

Through analysis above it can be seen that bicyclists of different ages are markedly different in terms of “traveling in the wrong direction” and “traveling too fast around the corner” and academic degree and income do not contribute to violation behavior differences of bicyclists; bicyclists of different genders are markedly different. On the whole bicyclists obtain points of 3.5-4.0.

Electrical bicyclists of different ages, academic degrees and income are not markedly different in terms of violation behavior; electrical bicyclists of different ages are markedly different. On the whole, electrical bicyclists obtain points of around 3.0.

It shows that majority personal attributes contribute little to non-motor violation and violation has become universal phenomenon in China.

On the other hand, it can be easily found that electrical bicyclists commit higher rate of violation if compared with bicyclists. It is probably because electrical bicycles are relatively faster, flexible and more impossible to control compared with bicycles.

Contributing Factors to Violation Rate of Non-motorist at Intersections

Through ANOVA analysis it can be found that violation rate of three types of surveyed intersections are markedly different. Through correlation analysis it can be found that violation rate is negatively correlated with intersection type, motor vehicle volume and total motor vehicle volume, while positively correlated with non-motor vehicle proportion and electrical bicycle proportion in non-motor vehicle. A-type intersection is the smallest intersection among the three, which is two-phase and has the slightest motor vehicle volume but the highest violation rate; non-motorists behave rather randomly at the intersection; C-type intersection is the largest intersection among the three, which boasts of complicated and reasonable phasing system as well as relatively heavier motor vehicle volume; as a result, it has the lowest non-motorist violation rate. When the proportion of electrical bicycle in non-motor vehicle gets larger, the violation rate of non-motorists gets higher probably. It certifies an above conclusion that electrical bicyclists commit higher rate of violation compared with bicyclists.

Characteristics of Non-motorist Violation Behavior at Types of Intersections

Through video recording and processing and analysis of violation behavior of non-motorist at three types of intersections it can be found that:

A-type intersection has the slightest motor volume and “running red lights” is rather conspicuous; non-motorists often make light of the consequences of violation behavior; even though some non-motorists stop at the red lights, they would wait beyond the line, thus disturbing the right-turning motor vehicle of the same entrance driveway.

As B-type intersection has unreasonable settings of left-turning phase easily, some non-motorist violation are likely to “running red lights” and “rushing forward just when the red light switches to green”; from the video of Jiefang Nanlu-Liuting Street intersection it can be seen that east-west non-motor vehicle lane is installed with shelters and as a result violation behavior such as parking outside the line has been significantly reduced.

C-type intersection boasts of reasonable signal phasing system and heavy motor vehicle volume, which gives great psychological pressure to non-motorists for the violation behavior, thus causing relatively lower rate of violation such as “running red lights” compared with the other two intersections. However, some non-motorists, who reach the intersection at the end of green light, still wish to speed up to cross the intersection; as the intersection is large and non-motor vehicle especially bicycles are slow, they can not cross the intersection during the green time; as a result, they are likely to collide with the motor vehicle at the intersecting road which start as long as signal light changes to green.

Insecurity of Non-motorist Violation Behavior

Table 9 shows that violation conflict rate of three types of intersections is above 0.5, among which violation conflict rate of C-type intersection reaches 0.8. It is thus clear that non-motorist violation is a major contributing factor to accidents at intersections.

Violation conflict number and total conflict number at intersections is positively correlated with violation rate, which indicates that the higher violation rate the more conflicts and higher conflict rate at intersections. A-type intersection has the highest conflict rate with the most violation conflicts and total conflicts.

Table 11 and figure 5 show that on the whole non-motorists “running red lights”, “traveling in the wrong direction” and “rushing forward at the end of green light” are most dangerous violations; specifically speaking, “running red lights” at B-type intersection is exposed to the highest degree of risk; all kinds of violation behavior demonstrate relatively higher degree of risk at C-type intersection, among which the risk degree of “rushing forward at the end of green light” and “traveling in the wrong direction” is higher than that of the other two intersections.

CONCLUSIONS AND SUGGESTIONS

Through questionnaire and video recording it can be concluded that:

(1) Majority personal attributes such as academic degree and income contribute little to non-motorist violation and violation has become universal phenomenon. Compared with bicyclists, electrical bicyclists have a higher frequency of violation.

(2) Violation rate is negatively correlated with phasing and total number of motor vehicle. Unreasonable setting of phases will result in increasing violation behavior such as “running red lights” and “rushing forward just when the red light switches to green”; shelters installed at non-motor lane can significantly check "parking outside the stop line" phenomenon; non-motorists at large-scale intersections are likely to “rushing forward at the end of green light”; non-motorists commit a higher rate of violation at small-scale intersections and often behave randomly.

(3) Non-motorist violation is the major factor to accidents at intersections. Conflict number and conflict rate at intersections are positively correlated with violation rate, namely, the higher violation rate, the more conflicts at intersections and the higher conflict rate.

(4) At intersections, non-motorists “running red lights”, “traveling in the wrong direction” and “rushing forward at the end of green light” are most dangerous among traffic violations, all kinds of violation behavior demonstrate relatively higher degree of risk at large-scale intersections, among which the risk degree of “rushing forward at the end of green light” and “traveling in the wrong direction” is higher than that of the small-scale intersections.

(5) The reasons why non-motorist violation at intersections is universal are integrated. Therefore, it is to construct perfect transportation projects, carry out in-depth and long-lasting education on traffic system, improve traffic regulations, and strengthen management on high-degree violation and traffic law enforcement with an aim to restoring favorable traffic order.

(6) Based on these research, the measure that combining moving stop line backwards and installing awning prevents the violations “parking outside the stop line” and “running red lights” of non-motorists in a certain extent. Especially in the hot summer, compared to the intersections which do not install the awning, lots of non-motorists will wait for the green light patiently under the awning, even more, they will return to hide in awning to wait when they parking over the stop line. Alternatively, the turning route of non-motor at intersections could be fixed explicitly; setting diversion island and specializing non-motor vehicle phase could separate motor vehicles and non-motorized vehicles from space-time to avoid the conflict effectively; at both the beginning and end of pedestrian green phase, the yellow light should be given enough time to ensure traffic safety of vulnerable groups especially in large intersection.

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