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Analyzing Electric Bicycle Rider's Unsafe Crossing Behavior Based on Theory of Planned Behavior

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Abstract

Electric bicycle riders, particularly youngsters, are one of the high risk groups of road transportation system. Previous studies were limited to the causes of electric bicycle accident, and failed to explore occurrence mechanism of accidents. For a better understanding of electric bicycle rider's unsafe crossing behavior, a questionnaire which contains TPB variables such as intention, attitude, subjective norm and perceived behavioral control was made based on the theory of planned behavior (TPB). Electric bicycle rider's unsafe crossing behavior model was established and tested by using AMOS 20.0 which is statistical software and can verify kinds of measurement model and path analysis model through structural equation modeling (SEM). Confirmatory factor analysis (CFA) and goodness-of-fit test indicates that TPB can well explain rider's unsafe crossing behavior. The results show that attitude toward unsafe crossing and perceived behavioral control have a positive effect on unsafe crossing intention, while otherwise for. Perceived behavioral control and unsafe crossing intention do contribute to the prediction of unsafe crossing behavior. Available advices on the avoidance of unsafe crossing have been suggested on organizing safety education and training, increasing the traffic safety awareness of riders and strengthening law enforcement strategies.

Keywords: Electric Bicycle Riders, Theory of Planned Behavior (TPB), Unsafe Crossing Behavior, Structural Equation

1 INTRODUCTION

As a modern transportation mode, electric bicycle is popular among all travelers, because of its traffic characteristics such as fast speed, low energy consumption, low pollution and so on. Electric bicycle is also an important tool for the passenger transfer of urban mass transit, which greatly reduces the time of mass transit transfer and contributes to attractiveness of mass transit (Zhou Lixin, 2001). However, the safety of electric bicycle riders is becoming a growing concern and the focus of discussion, and some cities have even experienced a management process for the use of electric bicycle from prohibition to permission. Because electric bicycle is fully operated by rider, rider's intention and behavior affect the movement track and safety (Wang Manli, 2009). Previous studies found that when crossing the street at the intersection, riders often show impulsive behaviors, such as exceeding the speed limit, taking up motor lanes, disobeying traffic signal and other typically illegal or unsafe behavior (Qin Bao, 2010). Therefore, the study on electric bicycle rider's crossing behavior has important significance.

For electric bicycle rider's crossing behavior at the intersection, the traditional method is mainly to observe riding behavior and law obedience (Shi Chenpeng, 2007). In addition, some of the current studies use traffic conflict techniques to analyze crossing behavior at the intersection, but they mainly analyze the conflict and avoidance between electric bicycles and motor vehicles and bicycles and pedestrians (Luo Jiangfan, 2008; Wan Manli, 2010). These methods are restricted to the analysis on rider's illegal or unsafe crossing behavior through external factors, and explain in which case riders are easy to choose unsafe crossing, but exclude from exploring the reason why riders do choose unsafe crossing. Therefore, in the course of investigating rider's unsafe crossing behavior, it is necessary to introduce social psychology. By analyzing the forming factors and process of rider's unsafe crossing behavior, the mechanism

of unsafe crossing behavior can be better explained.

The theory of planned behavior has previously been successfully applied to predict diverse behaviors such as driver's decision on speed, public transportation use and aggressive driving (Henriette Walle ń Warner, 2006; Ding Jingyan, 2006; Zhao Shanshan, 2011). In this study, therefore, the theory of planned behavior was applied to analyze electric bicycle rider's unsafe crossing behavior, and explore the relationship between unsafe crossing behavior and psychological factors such as attitude and subjective norm. By establishing rider's unsafe crossing behavior model using structural equation modeling, we can figure out the role of psychological factors and understand internal mechanism of rider's unsafe crossing behavior.

2 THEORY of PLANNED BEHAVIOR and RESEARCH HYPOTHESES

The theory of planned behavior (TPB) put forward by Ajzen(1985, 1991), the most famous theory on attitude-behavior in social psychology, is proved to significantly improve the research on behavior of explanatory power and prediction power. The core ideas of theory of planned behavior are that people's behavior is determined by their behavior intention which expresses the willingness of individual to take an action, and that the greater the behavioral intention is, the larger the likelihood of an individual to take action is. Attitude toward behavior, subjective norm and perceived behavioral control, the three factors that determine people's behavior intention, are the degree of individual to perform a certain behavior which is positive or negative; the perceived social pressure for individual to perform or not a specific behavior and the perceived difficulty for individual to perform or not a specific behavior, respectively. When accurately perceived behavioral control reflects the actual behavior control, it directly affects individual's behavior (Duan Wenting, 2008).

On the basis of TPB, this study proposes a hypothetical model with the following hypothesis, as seen in Fig.1.

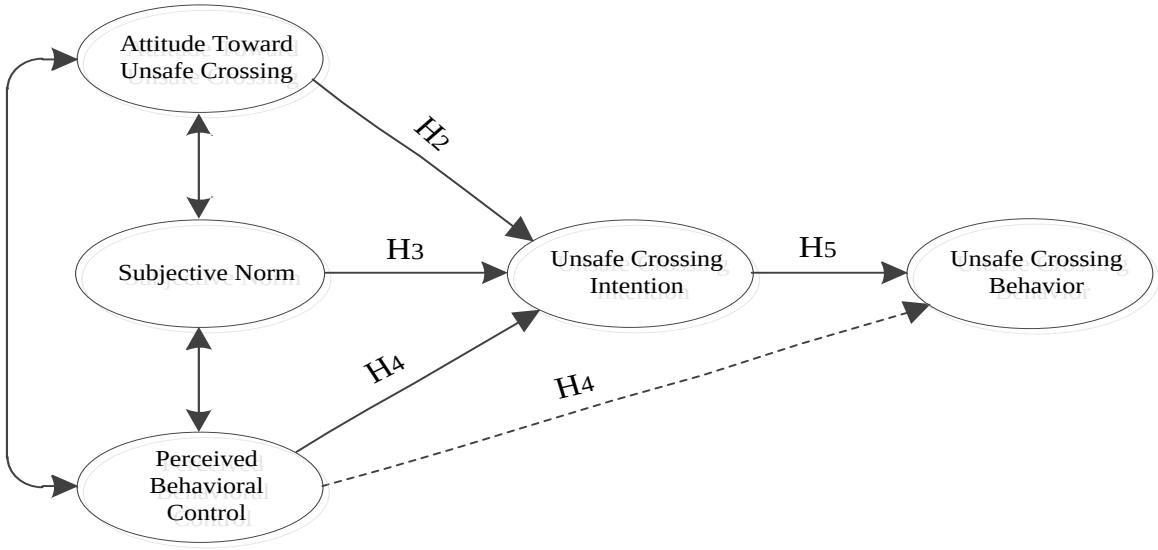

FIG.1 THE HYPOTHETICAL MODEL

H_1: The theory of planned behavior can well explain electric bicycle rider's unsafe crossing behavior. Psychological factors affecting unsafe crossing such as attitudes, and subjective norm can predict rider's unsafe crossing behavior through unsafe crossing intention.

H_2: Attitude toward unsafe crossing has a positive effect on unsafe crossing intention. The more positive rider's attitude toward unsafe behavior is, the stronger rider's unsafe behavior intention is.

H_3: Subjective norm has a negative effect on unsafe crossing intention.

H_4: Perceived behavioral control has a positive effect on unsafe crossing intention, and can directly predict rider's actual unsafe crossing behavior.

H_5: Unsafe crossing intention has a positive effect on Unsafe crossing behavior.

3 METHOD

3.1 Participants and Sample

The survey used both online and paper questionnaires. 253 questionnaires out of 300 distributed in Nanjing were returned from riders. After the deletion of inconsistent answers or incomplete responses, the 218 valid samples resulted, yielding an effective response rate of about 72.7%. The respondent data consisted of both male (62%) and female (38%). Riders at the age 21–30 (39.1%) and 31-40 (32.2%) accounted for the majority of the sample.

3.2 Measures

The questionnaire with all constructs under investigation was designed on the basis of the theory of planned behavior as a reference, and all questions were measured on five-point Likert scales, ranging from 1 meaning "strongly disagree" to 5 meaning "strongly agree". The questionnaire was divided into five dimensions (dimensions), including attitude toward unsafe crossing, subjective norm, perceived behavioral control, unsafe crossing intention and unsafe crossing behavior. Before formal investigation, a pre-test was carried out with randomly selected 35 electric bicycle riders. The survey was revised to improve validity and reliability based on feedback from the riders.

1) Attitude toward Unsafe Crossing

Seven items used to measure respondents' attitudes toward unsafe crossing are: 1) taking up vehicle lanes for the convenience of crossing; 2) speeding for saving time; 3) Making telephone calls while riding is not dangerous to their own safety; 4) unpunished for violation of traffic signal to cross the street; 5)the failure of traffic accidents while suddenly crossing the street; 6) one's habit of riding in parallel with others without too much attention; 7) riding in opposite direction free from interference with pedestrians or cars. Scale reliability based on Cronbach's α is 0.92, and over the threshold recommended by Hair et al. (2006), indicates that there is high internal consistency. On average, respondents tend not to agree to unsafe crossing in terms of attitude toward crossing (M=2.04, SD=0.84).

2) Subjective Norm

Subjective norm is measured by asking respondents whether other people who are important to them would support their unsafe crossing. Six items are used to measure, and other people include family, friends, colleagues, superior, traffic police and companions. The Cronbach's α coefficient is 0.91, indicating a high degree of scale reliability. On average, respondents thought that other people do not agree to unsafe crossing (M=1.93, SD=0.49).

3) Perceived Behavioral Control

Eight items used to measure respondents' control ability in unsafe crossing are: 1) as there is no motor vehicle near intersection, I am to cross the street directly; 2) in order to save time, I maybe quickly violate the rule to cross the street; 3) if traffic polices are absent in the intersection, I have an act of unsafe crossing; 4) if there is a camera in the intersection, I have an act of unsafe crossing; 5) if red light is too long, I'll cross the street quickly; 6) if someone is about to cross intersection unsafely, I will follow suit; 7) when traffic situation is mixed, I will be free to cross unsafely; 8) When friends or acquaintances instigate to unsafe crossing, I will follow suit. The Cronbach's α coefficient is 0.94, indicating a high degree of scale reliability. On average, respondents showed a relatively lower level of perceived behavioral control over unsafe crossing (M=2.35, SD=0.81).

4) Unsafe Crossing Intention

Unsafe crossing intention is measured through three items that are: 1) when riding electric bicycle, I am likely to cross unsafely; 2) when riding electric bicycle, I am willing to try to cross unsafely; 3) if unsafe crossing can be achieved, I am intent to do it. The Cronbach's α coefficient is 0.90, indicating a high degree of scale reliability. On average, respondents showed a relatively lower level of unsafe crossing intention (M=2.26, SD=0.79).

5) Unsafe Crossing Behavior

Unsafe crossing behavior was measured by 6 items, including: 1) I used to take up vehicle lines to unsafe crossing; 2) I am usually free to cross the street; 3) I do not comply with traffic signals to cross the street; 4) when crossing the

intersection, I am about to make telephone calls; 5) I used to speed up at the intersection; 6) I do ride in parallel with others at the intersection. The Cronbach's α coefficient is 0.94, indicating a high degree of scale reliability. On average, respondents showed a lower expectation on unsafe crossing (M=2.16, SD=0.75).

3.3 Data Analysis

Data analysis was divided into two steps. First, a confirmatory factor analysis was used to analyze whether the measurement variables reliably reflected the hypothesized latent variables (Brian s. Everitt and Graham Dunn, 2011). Then, the construction of the rider's unsafe crossing behavior model was carried out using structural equation modeling, and the model adequacy was assessed based on goodness-of-fit indices. The statistical software of AMOS 20.0 was used to analyze the data in this study.

4 RESULT

4.1 Confirmatory Factor Analysis

Before analyzing the structural equation modeling, confirmatory factor analysis was calculated for each dimension in the construction of the SEM model. AS shown in Table 1, all of the constructed dimensions demonstrate sufficiently high levels of internal consistency, reliability and validity.

As the latent variables indicators of reliability, composite reliability (CR) can detect the intrinsic quality of the model. Composite reliability values for the latent variables are over 0.6, which means that the intrinsic quality of the model is desirable (Bagozziand Yi, 1988). According to Table 1, all of the results for composite reliability of five latent variables in the SEM model are over 0.9, indicating that the scales have good level of internal consistency and the intrinsic quality of the SEM model is high.

TABLE 1 FIT STATISTICS BY DIMENSION FOR ALL CONFIRMATORY FACTOR ANALYSES

Latent variable	Items	Std. estimate	Std. error	Error variance	CR	AVE	p
Attitude toward unsafe crossing （ATUC）	ATUC1	0.702	-	0.073	0.924	0.636	-***
	ATUC2	0.849	0.174	0.059			-***
	ATUC3	0.801	0.138	0.042			-***
	ATUC4	0.857	0.176	0.052			-***
	ATUC5	0.845	0.140	0.035			-***
	ATUC6	0.753	0.144	0.051			-***
	ATUC7	0.761	0.138	0.044			-***
Subjective norm（SN）	SN1	0.807	0.145	0.030	0.914	0.640	-***
	SN2	0.885	0.160	0.027			-***
	SN3	0.753	0.147	0.036			-***
	SN4	0.839	0.157	0.031			-***
	SN5	0.752	0.156	0.040			-***
	SN6	0.755	-	0.030			-***
Perceived behavioral control （PBC）	PBC1	0.791	0.082	0.045	0.939	0.659	-***
	PBC2	0.872	0.077	0.033			-***
	PBC3	0.711	0.091	0.061			-***
	PBC4	0.741	0.088	0.055			-***
	PBC5	0.827	0.079	0.039			-***
	PBC6	0.888	0.082	0.034			-***
	PBC7	0.763	0.086	0.051			-***
	PBC8	0.881	-	0.035	0.900	0.750	-***
Unsafe crossing intention （UCI）	UCI1	0.816	-	0.040			-***
	UCI2	0.892	0.108	0.030			-***
	UCI3	0.887	0.110	0.033			-***

TABLE 1 FIT STATISTICS BY DIMENSION FOR ALL CONFIRMATORY FACTOR ANALYSES (CONTINUE)

Latent variable	Items	Std. estimate	Std. error	Error variance	CR	AVE	p
Unsafe crossing behavior （UCB）	UCB1	0.883	-	0.029	0.935	0.706	-***
	UCB2	0.851	0.079	0.030			-***
	UCB3	0.883	0.083	0.030			-***
	UCB4	0.814	0.082	0.035			-***
	UCB5	0.822	0.088	0.040			-***
	UCB6	0.784	0.093	0.048			-***

-***≤0.001

The average variance extracted (AVE) is the ratio of amount of variation which the indictor variables can explain by latent variables, and is an indicator of convergent validity. The greater its value is, the greater the percentage of amount of variation is, and the smaller the relative measurement error is. The general criterion that is the average variance extracted is over 0.5(Hair and Black, 2010). As shown in Table 1, the average variance extracted for each dimensions ranges from 0.636 to 0.750, which is over 0.5, indicating that the scales have good convergence validities.

4.2 Construction and Verification of Structural Equation Modeling

According to the theory of planned behavior, electric bicycle rider`s attitude toward unsafe crossing, subjective norm, perceived behavioral control and unsafe crossing intention can predict riders unsafe crossing behavior. A summary of the hypothetical model is shown in Fig.1. This paper uses SEM to analyze electric bicycle rider's unsafe crossing behavior, and its advantage is the ability to describe the degree of model fitting while modeling (Wu Minglong, 2009).

According to the statistical analysis of the survey data, the observed values of each dimension has been obtained, and the model of electric bicycle riders unsafe crossing behavior was established by using SEM to result in structural equation path diagram. In the structural equation path diagram, different symbols and arrows represent different meanings: the ovals represent latent variables; rectangle on behalf of the observed variables; unidirectional arrows express one-way influence or direct effect; bidirectional arrows reflect correlation or co-variation. The constructed structural equation path diagram is shown in Fig.2.

The electric bicycle rider's unsafe crossing behavior model is verified by using structural equations approach. The purpose of the model validation is to test the degree of model fitting, namely goodness-of-fit test. There are no consistent standards for goodness-of-fit test to be used in evaluating the adequacy of the model, and the pros and cons of goodness-of-fit indices do not guarantee that a model is useful. Therefore, the assessment of model adequacy must be based on multiple criteria taking into account theoretical, statistical, and practical considerations (Byrne, 2001).

This paper has utilized three different types of goodness-of-fit indices recommended by Hair and Babin (1998): 1) goodness-of-fit tests based on absolute fit indices like the model chi-square test, or RMSEA; 2) goodness-of-fit tests based on incremental fit measurement like NFI, or CFI; 3) goodness-of-fit tests based on parsimonious fit measurement like Chi square degrees of freedom, or PGFI. Goodness-of-fit indices for the structural equation model tested in this study are summarized in Table 2.

TABLE 2 THE GOODNESS-OF-FIT INDICES FOR ELECTRIC BICYCLE RIDE'S UNSAFE CROSSING BEHAVIOR MODEL

Indices	χ^2/df	GFI	NFI	CFI	IFI	TLI	PGFI	RMSEA
value	1.430	0.916	0.923	0.964	0.965	0.957	0.712	0.049

In the above table, χ^2=562.1, df=393, χ^2/df=1.430<2, and P=0.000; GFI, NFI, CFI, IFI, TLI>0.9; PGFI>0.5; RMSEA<0.05. The above goodness-of-fit indices are in line with the criteria, indicating that model fitting is good, and showing that the theory of planned behavior can well explain electric bicycle rider's unsafe crossing behavior. Unsafe psychological factors such as attitudes and subjective norms can predict rider's unsafe crossing behavior through unsafe crossing intention. Therefore, it can be proved that the hypothesis H_1 is established.

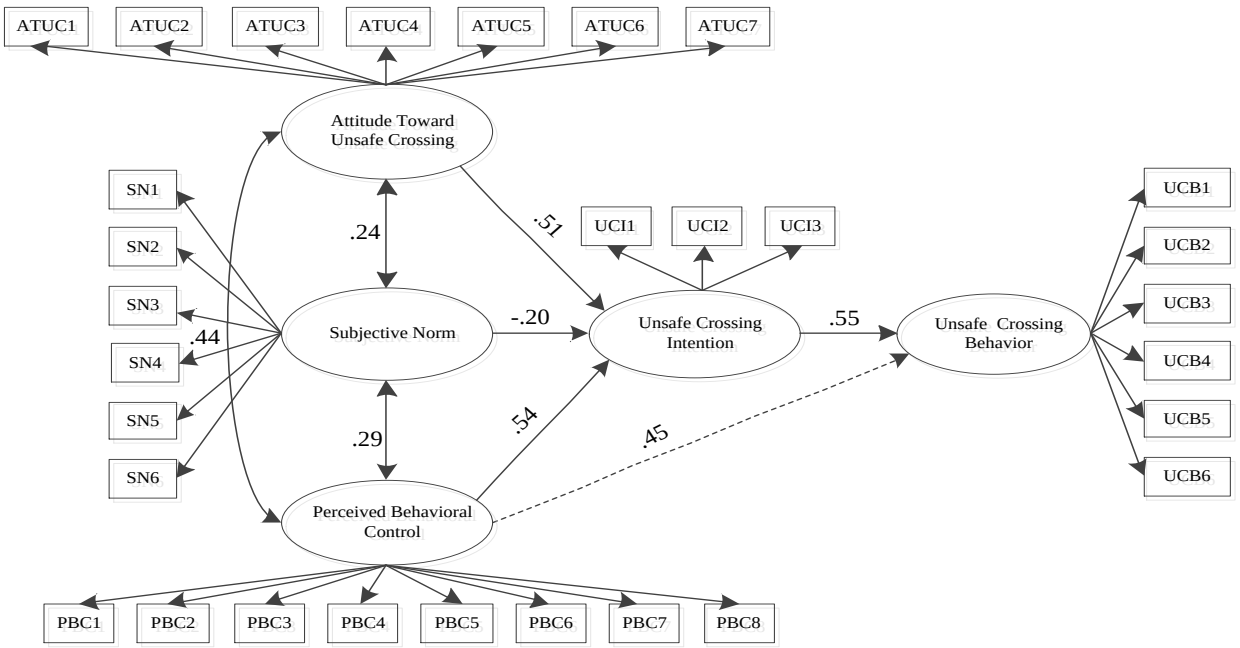

FIG.2. ELECTRIC BICYCLE RIDER'S UNSAFE CROSSING BEHAVIOR MODEL PATH DIAGRAM

5 DISCUSSION

The goal of this paper is to apply the theory of planned behavior to explore the relationship between unsafe crossing behavior and its psychological factors among electric bicycle riders. In this section, we use unsafe crossing behavior model path diagram to discuss relationship between the dimensions, namely the relationship between the latent variables, and discuss the implications of these results for rider's safe crossing.

1) Attitude toward unsafe crossing has significant relationship with crossing intention, which is positive correlation (the path coefficient is 0.51), and it can be confirmed that the hypothesis H_2 is valid. Attitude toward unsafe crossing in order to facilitate (M=2.34) and save time (M=2.25) shows that the respondents tend to oppose unsafe crossing behavior. When considering the danger (M=1.88) and punishment (M=1.78), respondents have a lower tendency, indicating that respondents have a clear understanding of unsafe crossing behavior and traffic management department, which can reduce rider's illegally crossing behavior by means of law enforcement and punishment.

2) Subjective norm has a negative effect on unsafe crossing intention (the path coefficient is -0.20), and is the only psychological factor capable to reduce rider's unsafe crossing intention. Therefore, the hypothesis H_3 is proved to be established. The results show that the respondents restrict their unsafe crossing behavior because of the persuasion of social relations, and also demonstrate that unsafe crossing behavior is not accepted in the criterion of social behavior. Among the whole social relations, family persuasion (M=1.79) has the greatest influence.

3) Perceived behavioral control is the deepest among all the factors affecting unsafe crossing intention (the path coefficient is 0.54), and demonstrates that riders unsafe crossing intention is heavily dependent on their self-control. The survey results show that when traffic polices are absent (M=3.02) and hurry (M=2.89), the respondents tend to cross unsafely, but when the streets is present with traffic polices (M=2.23) and monitor cameras (M=2.29), riders have lower tendency of unsafe crossing, indicating that riders are lack of awareness of safe crossing and traffic management department lack of regulation of unsafe crossing.

Perceived behavioral control can predict directly unsafe crossing behavior (the path coefficient is 0.45), indicating that in the actual control conditions, riders are involved in unsafe crossing behavior based on their self-control ability. Therefore, the hypothesis H_4 is proved to be established.

4) Unsafe crossing intention has a positive effect on actual crossing behavior (the path coefficient is 0.55), and can directly affect whether riders are involved in actual unsafe crossing behavior. The results show that the decline of unsafe crossing intention can effectively decrease actual crossing behavior, proving the hypothesis H_5 is established.

6 CONCLUSION

In this study, structural equation modeling has been applied to analyze electric bicycle rider's unsafe crossing behavior and established rider unsafe crossing behavior model path diagram based on theory of planned behavior by the questionnaire survey. Confirmatory factor analysis and goodness-of-fit test showed that the theory of planned behavior can explain rider's unsafe crossing behavior well.

By analyzing the relationship between TPB variables (i.e. subjective norm and perceived behavioral control), unsafe crossing intention and unsafe crossing behavior, it was found that attitude toward unsafe crossing and perceived behavioral control have positive effect on unsafe crossing intention and actual crossing behavior, while subjective norm has a significantly negative impact on unsafe crossing behavior. Therefore, these findings provided insights into better understanding on the unsafe crossing behavior of riders, as well as effective education and strategies for traffic department to improve rider's unsafe crossing.

In this paper, the conclusions were based on the limited relative samples (253 participants), the representativeness of the sample in regional and quantitative should be further considered, which will be researched in more large region and quantity. Moreover, the factors affecting safe crossing do not take into account riding experience of the riders and self-reported unsafe crossing, which is the shortcomings and should be improved for this study. Because of thesis length, besides, the study did not combined with external traffic running environment, different traffic facilities and traffic flow to observe ride's crossing behavior, which is emphasis and direction of further research in the future.

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