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An extension of the theory of planned behavior to predict pedestrians' violating crossing behavior using structural equation modeling

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ABSTRACT

This paper aimed to examine pedestrians' self-reported violating crossing behavior intentions by applying the theory of planned behavior (TPB). We studied the behavior intentions regarding instrumental attitude, subjective norm, perceived behavioral control, the three basic components of TPB, and extended the theory by adding new factors including descriptive norm, perceived risk and conformity tendency to evaluate their respective impacts on pedestrians' behavior intentions. A questionnaire presented with a scenario that pedestrians crossed the road violating the pedestrian lights at an intersection was designed, and the survey was conducted in Dalian, China. Based on the 260 complete and valid responses, reliability and validity of the data for each question was evaluated. The data were then analyzed by using the structural equation modeling (SEM). The results showed that people had a negative attitude toward the behavior of violating road-crossing rules; they perceived social influences from their family and friends; and they believed that this kind of risky behavior would potentially harm them in a traffic accident. The results also showed that instrumental attitude and subjective norm were significant in the basic TPB model. After adding descriptive norm, subjective norm was no more significant. Other models showed that conformity tendency was a strong predictor, indicating that the presence of other pedestrians would influence behavioral intention. The findings could help to design more effective interventions and safety campaigns, such as changing people's attitude toward this violation behavior, correcting the social norms, increasing their safety awareness, etc. in order to reduce pedestrians' road crossing violations.

1. Introduction

China is the world's most populous country and has the greater amount of pedestrians if everyone is considered as a pedestrian at a certain point of the day. In the midst of country's rapid urbanization and motorization, motor vehicle crashes involving pedestrians have become more and more frequent, partly because pedestrians put themselves in a risky situation either by violating traffic rules or by poor judgment. In China, the pedestrians' road-crossing behavior may be different from other countries. 40% of the travel is completed on foot, accompanied by very common traffic violations (Yang et al., 2006). According to Zhuang and Wu (2011), pedestrians preferred to crossing at unmarked roadways anxiously instead of waiting patiently at the curb. For those who decided to cross the street, 65.7% did not look around for vehicles during crossing; for those who looked at the oncoming vehicles only 11.4% stepped back and 31.9% dashed across.

As the most vulnerable road users, the pedestrian safety has been a great concern of the society. There has been a considerable amount of research trying to explore the factors that influence pedestrians' risky behavior. Koh et al. (2014) found that a person was more likely to violate on a 4-lane road with wide median compared to a 6- or 7-lane road; and when he/she was alone compared to with companions. The factors contributing to a high possibility of violation also include crossing distance, waiting time, the number of passing vehicles, and the violating pedestrians. Xu et al. (2013) studied jaywalkers and evaluated their influence of past behavior. They found that the past behavior explained 42% of the variance in pedestrians' intention to violate traffic laws. A successful previous experience to violate traffic laws at the same location would prompt the chance of repeating offenses. On the other hand, the experience of being involved in a traffic accident would constraint the pedestrian from taking risks by reducing their waiting time, as reported by Hamed (2001). When demographic characteristics such as age and gender were considered, young people were found

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to have more positive attitude toward committing violations than adults, older people were less likely to cross in risky situations, and male pedestrians reported more frequent violations of traffic rules than females (Díaz, 2002; Holland and Hill, 2007).

The theory of planned behavior (TPB), developed by Ajzen (1991), is a social psychological model that has been successfully used to predict a wide range of health behavior and intentions, According to this theory, an individual's behavior can be predicted by the behavioral intention, which is a model of an individual's (1) attitude toward the behavior, a favorable or unfavorable evaluation of the behavior of interest, (2) subjective norm, the belief about certain people that are important to the individual may approve or disapprove the behavior, and (3) perceived behavioral control, people's perceptions of the ability to perform a given behavior. Whether a variable significantly contributes to the intention to perform the behavior depends on the type of behavior assessed and the target population (Ajzen, 1991; Ajzen and Fishbein, 2005). Studies have demonstrated the use of predictive utility of TPB to better understand the decision making process of the people who violate traffic rules (Forward, 2009; Iversen, 2004; Zhou et al., 2009; Castanier et al., 2013). Studies by Evans and Norman (1998, 2003) found that the three components of the theory were significant predictors of pedestrians' road crossing intention, but perceived behavioral control emerged as the strongest predictor, indicating that people were more likely to engage when the behavior was perceived to be easy.

The contribution of subjective norms was controversial (Armitage and Conner, 2001; Hausenblas et al., 1997). Researchers argued that when trying to assess social norms, three dimensions must be taken into consideration: subjective norm, descriptive norm, and personal norm. Descriptive norm was defined as an individual's perception of the actual performance of the behavior by others in one's social network, regardless of whether this behavior was morally correct. In most of the studies with descriptive norm included, descriptive norm contributed to behavioral intention independent of subjective norm (Rivis and Sheeran, 2003; Oceja and Berenguer, 2009).

TPB has been coupled with other factors such as conformity tendency, a tendency to modify behavior when a person is around other people so as to match the perceived expectation of the social conformity. A study conducted to explore the effect of conformity tendency on pedestrians' road-crossing intentions in China (Zhou et al., 2009) found that pedestrians reported greater chance of crossing the road when other pedestrians were crossing, and people who showed greater tendency toward social conformity had stronger road-crossing intention than low conformity people.

Besides TPB, another commonly used behavior model is the health belief model (HBM), a psychological model developed in 1950s to explain and predict health-related behavior. This model includes five components: perceived benefits, perceived barriers, perceived susceptibility, perceived severity, and cues to action. Perceived susceptibility and perceived severity refer to a person's subjective perception of the chances of getting a condition and how serious a condition can be, respectively. Yagil (2000) applied HBM to study pedestrians' road-crossing behavior in relation to their beliefs regarding the consequences of the behavior, incorporating instrumental and normative motives for compliance with safety rules and situational factors. Quine et al. (1998) compared the two theories, TBP and HBM, when predicting bicycle helmet use. The results showed that TPB could explain 43% of the variance while HBM could only explain 18%. A study on the seat belt use compared TBP, extended TBP and HBM, and the results showed that the TBP model has a better fit than the extended TPB and HBM model. In the TPB model, attitudes and subjective norm has a positive relationship to the seat belt use intention (Şimşekoğluand Lajunen, 2008).

Based on previous findings, this study used the basic framework of TPB to examine pedestrians' violating road-crossing behavior intention regarding attitudes, subjective norms, and perceived behavioral control. In addition to the three basic components of TPB, new factors such as descriptive norms, perceived risk and conformity tendency were tested to assess their influences on the pedestrians' behavior intention.

2. Method

2.1. Questionnaire and survey

Data for this study were collected from the survey. A carefully designed questionnaire was the first step to ensure that the data were reliable and valid for further analysis. The questionnaire for this study consisted of three parts. The first part was the scenario: "You are on your way to school, work or to handle some affairs and you must go to the other side of the road. You reach an intersection and the current pedestrian signal displays red light. You are in a hurry so you take your chance and cross the road in a gap in the traffic." The second part consisted of several questions about the respondents' demographic characteristics like age, gender, educational level, income, etc. followed by the third part focusing on items that were used to assess different constructs of TPB, including the intention to perform the behavior described in the scenario, instrumental attitude, subjective norm, perceived behavioral control, descriptive norm, perceived risk and conformity tendency. The items for each construct are described in the next section.

Prior to the formal survey for this study, a wide range of items in different constructs with a small group of people (35 in total) were tested in order to make sure that each item in the questionnaire was clearly described and easily understood. Cronbach's alpha (α) correlation test and principle component analysis (PCA) were conducted. Only those reliable and valid items through the tests were retained.

The formal survey was conducted in the city center of Dalian, China. Respondents were randomly selected, individually approached, and asked to participate in the study on pedestrians' road-crossing behavior by our interviewers in a public place. Under their agreements, respondents completed a written questionnaire. For those who had difficulty of reading, the interviewers read and explained the questions to them.

A careful examination was conducted for the total of 300 questionnaires collected and the questionnaires with missing data were removed, reducing the number of questionnaires to 260. Among the 260 respondents, the distributions of their age, gender, educational background, income, holding a driver license, and driving frequency were described in Table 1. Descriptive statistics showed that 57.3% of the respondents were female and 42.7% were males. Nearly half of the respondents (49.2%) ranged from 18 to 24 years old and more than one third (33.1%) ranged from 25 to 39. 58.5% had an undergraduate degree, 18.1% finished high school and 12.7% finished middle school. 45.9% received a monthly income 2000–5000 yuan, and 38.1% received less than 2000 yuan. Respondents who had a driver license accounted for 68.1%, but most of them do not drive (78.1%), or rarely drive (9.6%).

2.2. Data reliability and validity

For each construct, the internal consistency of the items should be evaluated for the reliability of the survey data. Cronbach's alpha (α) correlation test was performed. A Cronbach's alpha (α) generally ranges between 0 and 1. The closer it is to 1, the greater the internal consistency of the items in the construct (Nunnally and Bernstein, 1994). Validity of the items was tested

Table 1
Distribution of the respondents in age, gender, educational level, income, holding a driver license and driving frequency.

	Freq.	Percent (%)	Cum. percent (%)		Freq.	Percent (%)	Cum. percent (%)
Age				**Gender**			
<17	15	5.8	5.8	Male	111	42.7	42.7
18–24	128	49.2	55.0	Female	149	57.3	100.0
25–39	86	33.1	88.1	**Monthly income (yuan)**			
40–60	23	8.8	96.9	<2000	99	38.1	38.1
>60	8	3.1	100.0	2000–5000	122	46.9	85.0
Education				5000–8000	28	10.8	95.8
Primary school	8	3.1	3.1	8000–10000	6	2.3	98.1
Middle school	33	12.7	15.8	>10000	5	1.9	100.0
High school	47	18.1	33.8	**Driving frequency**			
Undergraduate	152	58.5	92.3	Never	203	78.1	78.1
Postgraduate	20	7.7	100.0	Rarely	25	9.6	87.7
Driver license				Sometimes	12	4.6	92.3
With	83	31.9	31.9	Frequently	14	5.4	97.7
Without	177	68.1	100.0	Almost everyday	6	2.3	100.0

by the confirmatory factor analysis (CFA) which evaluates a priori hypothesis on what items should be associated with what factors. CFA was conducted in the software SPSS, using principle component analysis (PCA) as the extraction method.

2.2.1. Behavioral intention (BI)

This construct was measured by two items, which were: "Would you cross the road as described in the scenario?"; "If you encounter this situation in the future you would cross the road as described in the scenario", rated on a 7-point scale from strongly disagree (1) to strongly agree (7) (the same as below, except for instrumental attitude and subjective norm). PCA identified a single component, accounting for 80% of the variance. Internal consistency was strong, with a Cronbach's alpha (α) of 0.75.

2.2.2. Instrumental attitude (IA)

Instrumental attitude was assessed indirectly by using a belief based measure, which is obtained by calculating the product of the belief and the corresponding outcome evaluation. Respondents were presented with two behavioral beliefs, which were: "Crossing the road in the scenario described would save me time", and "Crossing the road in the scenario described would be more convenient". The responses ranged from strongly disagree (−3) to strongly agree (3) on a 7-point scale. An outcome evaluation of each belief was provided: "Saving time is important to you", and "Convenience is important to you". The response was from strongly disagree (1) to strongly agree (7). PCA identified a single component accounting for 77% of the variance and Cronbach's alpha (α) is 0.70.

2.2.3. Subjective norm (SN)

Similar to instrumental attitude, subjective norm was also measured indirectly. Two groups were used in this construct for the normative belief (family and friends): "My family would agree if I cross the scenario in the scenario described", and "My friends would agree if I cross the scenario described", scored from strongly disagree (−3) to strongly agree (3). As to the motivation to comply with them, they were asked: "In daily life I would comply with my family's opinion", "In daily life I would comply with my friends' opinion", scored from strongly disagree (1) to strongly agree (7). The product of the normative belief and the motivation to comply was calculated. These items measured a single component in PCA, accounting for 87% of the variance, with a Cronbach's alpha (α) of 0.85.

2.2.4. Perceived behavioral control (PBC)

PBC was assessed by two items: "I have the ability to cross the road as described in the scenario" and "It's easy for me to cross the road as described in the scenario". PCA identified a single component accounting for 76% of the variance, with a Cronbach's alpha (α) of 0.68.

2.2.5. Descriptive norm (DN)

Each respondents was asked about whether each references (family and friends in our study) performs the behavior: "My family cross the road as described in the scenario", and "My friends cross the road as described in the scenario". These items measured a single component in PCA, accounting for 87% of the variance, with a Cronbach's alpha (α) of 0.85.

2.2.6. Perceived risk (PR)

Perceived risk of getting involved in an accident was measured by asking: "I would get seriously injured if I cross the road as described in the scenario", "If I cross the road as described in the scenario I would endanger my life". These items measured a single component in PCA, accounting for 95% of the variance, with a Cronbach's alpha (α) of 0.95.

2.2.7. Conformity tendency (CT)

Conformity tendency was measured by two items: "If other pedestrians cross the road during the red light, I would do the same", and "When I am with companions I cross the road as described in the scenario". The second question did not specifically state whether or not the companions crossed against the light as the first one, so the internal consistency of the two items was calculated. The results of PCA showed that these two items measured a single component, accounting for 82% of the variance, and the Cronbach's alpha (α) is 0.78, suggesting acceptable reliability and validity of the data.

2.3. Correlation matrix

Table 2 presents the correlation for all the study variables. Instrumental attitude, subjective norm, descriptive norm, perceived behavioral control and conformity tendency were found to be positively correlated to behavioral intention, whereas perceived risk was found to be negatively associated but the result was not significant. Besides, items within the same construct were highly correlated with values greater than 0.5.

2.4. Descriptive statistics

Table 3 presents the means and standard deviations of the scores for each item under study. It was deduced from the results that overall the respondents did not agree that they would cross the road as depicted in the scenario (mean = 2.76) and that they would do it in the future (mean = 3.22). They did not agree that crossing

Table 2
Correlations among the variables ($n = 260$).

		BI		IA		SN		DN		PBC		PR		CT	
		1	2	7	8	13	14	15	16	17	18	19	20	21	22
BI	1	1	0.596**	0.333**	0.300**	0.293**	0.304**	0.373**	0.403**	0.299**	0.299**	−0.032	−0.074	0.398**	0.374**
	2		1	0.406**	0.328**	0.348**	0.342**	0.365**	0.361**	0.292**	0.254**	−0.073	−0.122*	0.365**	0.384**
IA	7			1	0.544**	0.252**	0.245**	0.228**	0.346**	0.331**	0.157*	−0.186**	−0.189**	0.373**	0.406**
	8				1	0.324**	0.336**	0.230**	0.305**	0.348**	0.130*	−0.215**	−0.256**	0.251**	0.288**
SN	13					1	0.747**	0.393**	0.351**	0.271**	0.099	−0.233**	−0.277**	0.225**	0.287**
	14						1	0.404**	0.458**	0.260**	0.111	−0.193**	−0.208**	0.278**	0.316**
DN	15							1	0.739**	0.354**	0.323**	−0.193**	−0.212**	0.351**	0.411**
	16								1	0.386**	0.252**	−0.168**	−0.167**	0.405**	0.416**
PBC	17									1	0.511**	−0.205**	−0.193**	0.285**	0.324**
	18										1	0.052	0.020	0.201**	0.185**
PR	19											1	0.900**	−0.129*	−0.226**
	20												1	−0.137*	−0.203**
CT	21													1	0.636**
	22														1

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

in this way would save time, or it would be convenient. However, they thought both saving time and convenience were important. The combining effects on time-saving (mean = −1.66) and convenience (mean = −5.40) told that respondents' attitudes toward the road-crossing behavior were negative. The respondents believed that their family and friends would not approve them of crossing the road when the traffic lights were red. They were willing to comply with what family and friends thought they should do. They did not think that their family (mean = 2.93) and friends (mean = 3.20) would cross the road as described in the scenario. They considered it to be easy to cross the road in such a way (mean = 3.55), but when it came to scenario described, responses were slightly negative (mean = 3.87) because they believed that there was a high probability that they would get injured in a car accidents (mean = 5.77) and could endanger their lives (mean = 5.83). They would not cross the road against the traffic light even if other pedestrians did so (mean = 3.63), nor would they do it when companied by others (mean = 3.21).

3. Results of the structural equation modeling (SEM)

The data were further investigated using the structural equation modeling (SEM) (Byrne, 2010). A series of models were built with the objective of identifying the contributions of standard and extended components in TPB to predict pedestrians' violating

Table 3
Mean and standard deviation of the score for each item.

		All cases		Male		Female	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Behavior intention							
Item 1	Cross the road	2.76	1.45	2.65	1.51	2.84	1.40
Item 2	Cross the road in the future	3.22	1.52	3.10	1.48	3.30	1.55
Instrumental attitude							
Item 3	Saving time	−0.52	1.71	−0.74	1.71	−0.36	1.71
Item 4	Convenience	−1.27	1.55	−1.38	1.48	−1.19	1.61
Item 5	Importance of saving time	4.40	1.46	4.37	1.67	4.42	1.28
Item 6	Importance of convenience	4.42	1.47	4.28	1.62	4.52	1.35
Item 7	Item 3 × Item5	−1.66	7.84	−2.55	7.85	−0.99	7.79
Item 8	Item 4 × Item6	−5.40	7.56	−5.57	7.44	−5.28	7.67
Subjective norm							
Item 9	Family approval	−2.02	1.04	−1.95	1.01	−2.07	1.07
Item 10	Friends approval	−1.69	1.26	−1.56	1.27	−1.79	1.26
Item 11	Compliance with family	5.12	1.45	5.23	1.44	5.05	1.45
Item 12	Compliance with friends	4.89	1.40	4.90	1.52	4.89	1.32
Item 13	Item 9 × Item 11	−10.35	6.62	−10.06	6.57	−10.56	6.68
Item 14	Item 10 × Item 12	−8.23	7.14	−7.52	7.25	−8.75	7.04
Descriptive norm							
Item 15	Family crossing behavior	2.93	1.43	2.93	1.52	2.93	1.36
Item 16	Friends crossing behavior	3.20	1.46	3.12	1.55	3.27	1.39
Perceived behavioral control							
Item 17	Ease of crossing the road	3.55	1.70	3.66	1.84	3.47	1.58
Item 18	Capability of crossing the road	3.87	1.72	3.99	1.78	3.77	1.69
Perceived risk							
Item 19	Get injured in a car accident	5.77	1.25	5.79	1.22	5.74	1.27
Item 20	Endanger life	5.83	1.22	5.85	1.23	5.81	1.21
Conformity tendency							
Item 21	Others cross the road	3.63	1.75	3.56	1.88	3.68	1.66
Item 22	With companion	3.21	1.60	3.08	1.61	3.31	1.59

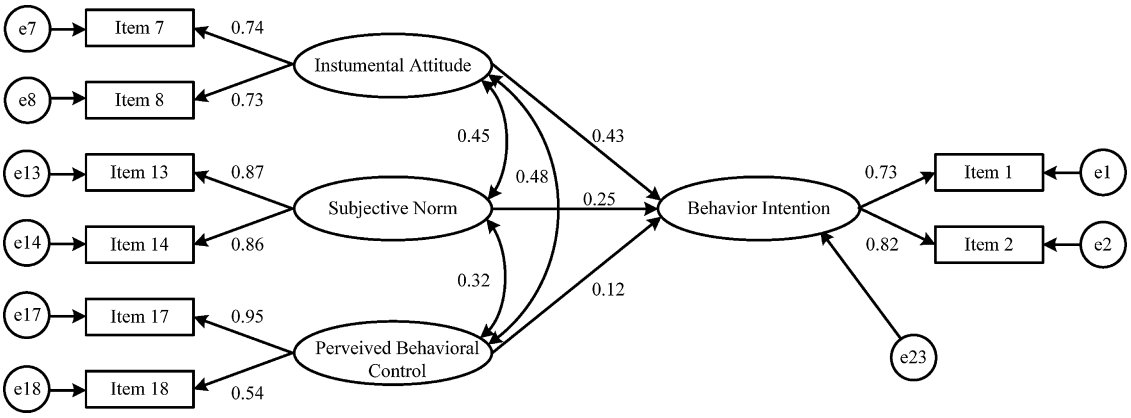

Fig. 1. Standard regression weighst and correlations for Model 1.

behavior intention. Maximum likelihood estimation was applied by comparing the actual covariance matrices representing the relationships between variables and the estimated covariance matrices of the fitted model. Model fit was assessed by multiple indices including the CMIN/df ratio (chi-square divided by degrees of freedom), the root mean square error of approximation (RMSEA) and PCLOSE (the *P* value for RMSEA), and comparative fit index (CFI).

3.1. Model 1 (basic model)

In the first step the three standard components in TBP were analyzed: instrumental attitude, subjective norm and perceived behavioral control. Fig. 1 showed that all the items highly loaded on their respective constructs with values greater than 0.5.

3.2. Model 2

In Model 2 descriptive norm was added to the basic model. As shown in Fig. 2, all the items highly loaded on their respective constructs. There was a high correlation between subjective norm and descriptive norm due to the fact that both were used to assess the peer influence. Instrumental attitude was also highly correlated with perceived behavioral control.

3.3. Model 3

The third model included instrumental attitude, descriptive norm and perceived risk. All the items highly loaded on their constructs. Perceived risk was negatively correlated with the other constructs (Fig. 3).

3.4. Model 4

In this model, instrumental attitude, descriptive norm, and conformity tendency were included. All the items highly loaded on their respective constructs. Conformity tendency was highly correlated with instrumental attitude and descriptive norm (Fig. 4).

Table 4 displays goodness of fit indices for the models. All four models provided adequate goodness of fit, and Model 4 is the best model.

Table 5 shows the unstandardized regression weights for each construct in the models. In Model 1, the basic model, instrumental attitude and subjective norm were significant predictors of behavioral intention. In Model 2 and Model 3, only instrumental attitude and descriptive norm were significant. In Model 4, instrumental attitude, descriptive norm, and conformity tendency were significant predictors of behavioral intention.

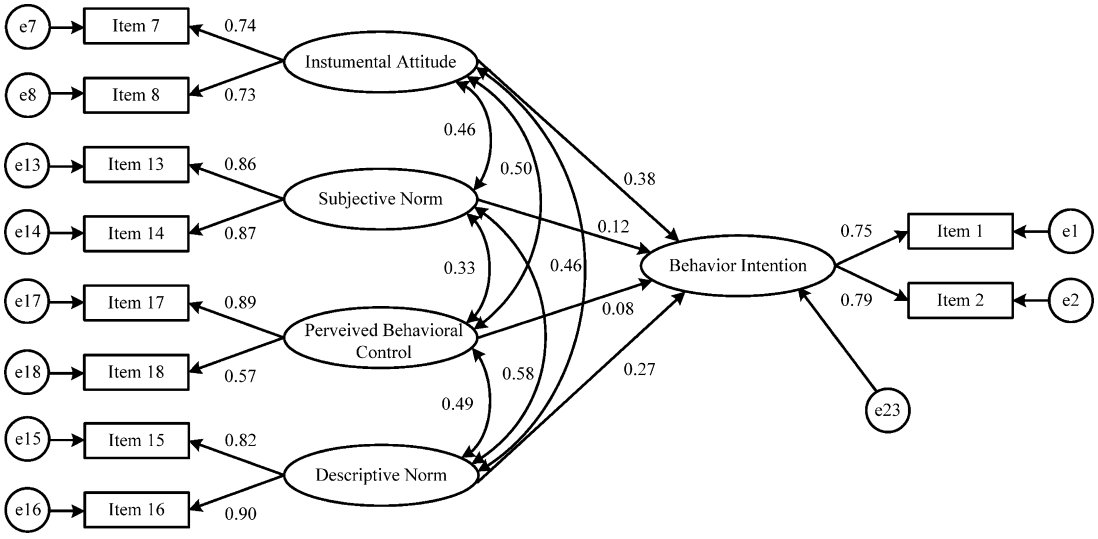

Fig. 2. Standard regression weights and correlations for Model 2.

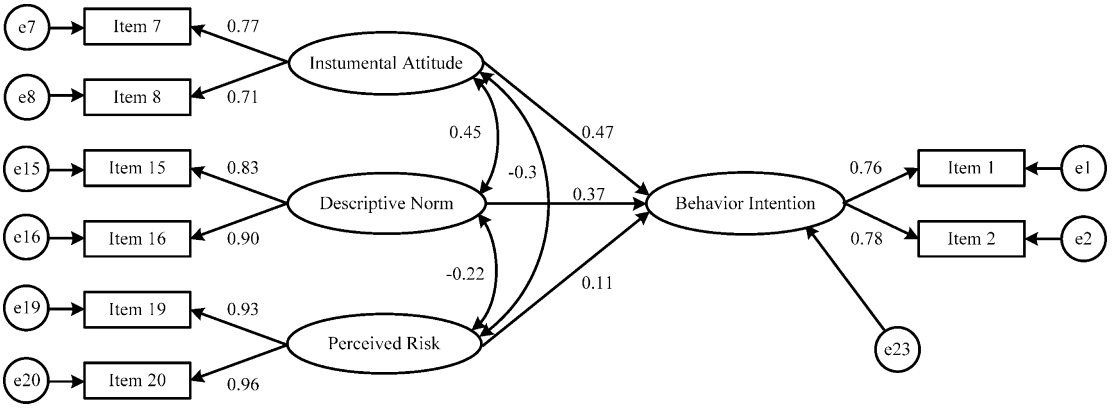

Fig. 3. Standard regression weights and correlations for Model 3.

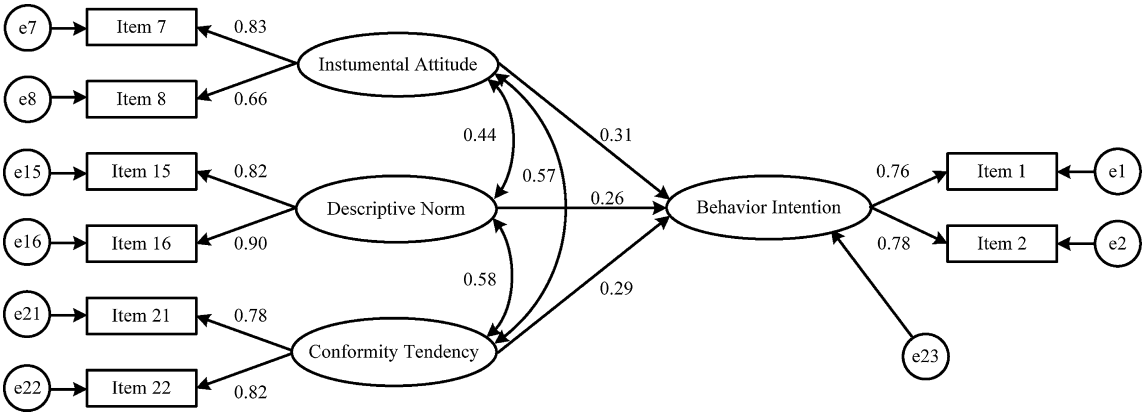

Fig. 4. Standard regression weights and correlations for Model 4.

Table 4
Summary of the goodness of fit for all the models.

	Model 1	Model 2	Model 3	Model 4
CMIN	21.429	39.507	22.53	17.29
DF	14	24	14	14
CMIN/DF	1.531	1.646	1.609	1.235
RMSEA	0.045	0.05	0.049	0.030
P-close	0.54	0.469	0.484	0.749
CFI	0.989	0.984	0.991	0.996

Table 5
Regression weights of the constructs.

	Model 1			Model 2			Model 3			Model 4		
	Estimate	S.E.	*P*	Estimate	S.E.	*P*	Estimate	S.E.	*P*	Estimate	S.E.	*P*
IA	0.082	0.021	**	0.075	0.021	**	0.096	0.021	**	0.070	0.022	**
SN	0.043	0.014	0.003*	0.021	0.016	0.186						
PBC	0.138	0.092	0.136	0.100	0.100	0.315						
DN				0.223	0.083	0.007*	0.314	0.073	**	0.217	0.0917	0.008*
PR							0.103	0.064	0.111			
CT										0.243	0.075	0.004*

* Significant at 0.01.
** Significant at 0.001.

4. Discussion

4.1. Predictors of behavioral intention

When applying the three standard components of TPB to predict pedestrians' violating road-crossing behavior, instrumental attitude and subjective norm were found to be significant. When descriptive norm was added to the model, the only significant predictor from the basic TPB model was instrumental attitude. The findings supported the use of factors: descriptive norm, conformity tendency, together with instrumental attitude to predict pedestrians' violations, as confirmed in Model 4. Each predictor in the models is discussed below.

Instrumental attitude was significant in all models, an unequivocal evidence that pedestrians are willing to take the risk to cross the road if this behavior is associated with meaningful benefits,

e.g., saving time or providing convenience, etc. This was consistent with the findings that a pedestrian would generally want to cross the road where it was more convenient in order to get to the destination with as little delay as possible (Daff and Cramphorn, 1994).

Subjective norm was significant in Model 1, indicating that pedestrians were influenced by their family members or friends. If the behavior was approved by these important referents, pedestrians were more likely to conduct it. However, when descriptive norm was added to the model, subjective norm was no longer significant. This is because subjective norm and descriptive norm both evaluated the influence from important referents with high correlation. Based on the results, descriptive norm appeared to be a stronger predictor than subjective norm. In other words, the action of the family members and friends is more influential on pedestrians than whether or not they approve of the behavior. This is supported by studies that most of human behavior was learned by observing (Peng et al., 2005). By observing family and friends violate traffic laws, an individual would imitate the behavior. It's worth mentioning that descriptive norm is not always a significant predictor to the behavior intention, but it would have greater influence in predicting behavior that carries some form of risk (Rivis and Sheeran, 2003), e.g., pedestrians crossing the road against the traffic rules.

Perceived behavioral control was not a significant predictor in Models 1 and 2. PBC intends to evaluate the person's ability to perform the behavior. A plausible explanation is that none of the respondents were physically impaired or disabled to cross the street. Comparing with other behavior such as quitting smoking, drug use, etc. where TPB has been successfully applied, violating road-crossing behavior seemed to be less challenging. Had the scenario been described in a more risky or intimidating fashion (e.g., wider road to cross, high speed traffic, etc.), the results would have been different. Further research is required to verify this viewpoint.

It is logical to believe that when people perceive that they are at risk by doing something they will avoid it. In this study, perceived risk was not a significant predictor of the violating behavior. It does not necessarily mean that perceived risk had no effect on pedestrians' behavior; rather, it probably means that pedestrians did not adequately perceive the susceptibility and seriousness of the risk pertaining to such violations. When people perceive risk as being uncontrollable with possible fatal consequences, they avoid it.

People of high conformity tendency were more likely to cross the road against the traffic light because they were more likely to be affected by other pedestrians' violating behavior. When people cross the road in groups, they probably feel less pressure from the social norm, and feel safer because drivers may slow down for a group of pedestrians rather than one single pedestrian. However, it should be noted that this low risk perception when crossing in groups may lead to false security, resulting in higher probability of traffic accidents.

4.2. Implications of developing safety interventions

Safety interventions that try to change road-users' behavior should not only rely on engineering countermeasures, but also on safety education of the knowledge and skills, law enforcement, change of people's attitudes, correcting social norms, increasing people's safety awareness, and so on.

Instrumental attitude significantly affects people's violating road-crossing behavior. The education programs should emphasize the gain of violation behavior (e.g., saving time or providing convenience) is actually very marginal and not worth the risk. Equally important is to emphasize the danger involved and the consequence resulted in such violation behavior to those who fail to realize or underestimate the risk of crossing the road against the traffic law.

Social norms may be enhanced by means of education as well. Since people's behavior may be influenced by observing the behavior of others, a campaign can inform the pedestrians that if one of them crosses the road in a proper way (e.g., using underpasses, overpasses or waiting for the traffic light), others as well as their family and friends would follow. So they not only protect their own lives but also others'. In this way the pedestrians can perceive a positive influence to the society through their improved behavior. School-based education is an important means to let children and younger people acquire correct social norms. Parents should also be the target groups for interventions because they are the role models of their children. And their children may become examples for their peers as well.

5. Conclusions

This paper applied the framework of TPB to study pedestrians' violating crossing behavior intention and expanded the theory by adding descriptive norm, perceived risk and conformity tendency. According to the survey data, people had an overall negative attitude toward the violating road-crossing behavior, their family and friends generally disapproved of such behavior, and they believed that this kind of behavior would increase the probability of getting them injured or killed in a traffic accident. Structural equation modeling results showed that instrumental attitude, descriptive norm, and conformity tendency were significant predictors of the violating crossing behavior and a model containing these three constructs provided better predictive utility than the basic TPB model. Subjective norm became insignificant after descriptive norm was added to the model, suggesting that pedestrians' observations of the family and friends' behavior had greater influence than perceived approval from them. Contrary to the findings of other research, perceived behavioral control, a standard component of TPB, was not significant. Perceived risk was not significant, indicating that pedestrians probably failed to realize the danger of this behavior. The findings provided further implications for designing interventions to change people's behavior through education and social awareness campaigns.

Some limitations of the study can be investigated further. One is the bias of reported behavior, especially negative behavior. Actual behavior should be observed for comparison or validation. Another is the relatively small number of items. In order to keep high internal reliability of the data, a small number of items were included in the final questionnaire, which could affect the results. In the future studies, it is desirable to increase the number of items in each construct. Finally, although perceived behavior control was not significant in this study, future study is necessary to investigate its effects under scenarios that represent different levels of difficulty.

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