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Socio-Cognitive Determinants of Pedestrians' Intention to Cross on a Red Light Signal: An Application of the Theory of Planned Behaviour

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Abstract: The present research describes the development and validation of a self-reported instrument that measures the determinants of pedestrians' intention to violate traffic rules, based on the theory of planned behaviour. Moreover, the research deals with the analysis of the predictive validity of an extended theoretical framework of the theory of planned behaviour in relation to pedestrians' intention to violate. Based on the quota sample, adult pedestrian respondents (n = 383) completed a questionnaire assessing the relevant variables. Valid and reliable scales were developed, and they measure subjective, descriptive, normative, and personal norms, cognitive and affective attitudes, perceived behavioural control, habit formation, and behavioural intention concerning pedestrians' misdemeanour. Hierarchical regression analysis indicated that all components, except descriptive norms, were significant simultaneous predictors of pedestrians' intention to violate. The most powerful predictor is the personal norm. Overall, the findings considerably support the concept of the extended theoretical framework of the theory of planned behaviour.

Keywords: pedestrian; violation intention; scale development; theory of planned behaviour; road safety

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1. Introduction

1.1. Background

The deaths of vulnerable road users, especially pedestrians, cause great concern in the public. Vulnerable road users account for half of the overall number of fatalities in traffic accidents worldwide, and 23% of them are pedestrians [1]. In Serbia, the percentage of fatally injured pedestrians in the overall number of fatalities is 23%, which is twice as many as in developed countries [1]. Traffic accidents involving pedestrians usually occur in urban areas where pedestrian activity and the volume of traffic are increased. In the USA, in 2021, fatally injured pedestrians in urban areas made up more than three-quarters of the overall number of fatally injured pedestrians [2]. Studies performed in Europe showed similar patterns, where in 2017, 70% of all vulnerable road user deaths occurred on urban roads [3]. In urban areas, pedestrians are exposed to traffic accident risk mainly during intersection crossings and at mid-block locations [4–7]. Intersections represent critical locations where conflicting situations between pedestrians and several other road users take place. Even after the introduction of traffic light signalling, road accidents involving pedestrians still happen at these locations [8,9]. This can be explained by the fact that neither drivers nor pedestrians follow the rules of traffic light signalling. Studies have shown that the most common pedestrian offences are illegal crossings during a red-light phase [10–15]. Keegan and O'Mahony [16] highlighted in their research that 35% of pedestrians cross against a red light. Studies confirm that pedestrians who cross against a red light are exposed to a higher accident risk [15,16]. In addition, King et al. [17] determined that pedestrians who crossed against the red light accounted for 13% of the overall percentage of pedestrians at signalised intersections, and there were approximately eight times as many crashes per crossing event as there were legal crossings. In Sweden, most traffic accidents with pedestrian participation at signalised intersections occurred during vehicles' turning manoeuvres and because pedestrians crossed on a red light [18]. Pedestrians are prone to risky behaviour even in favourable infrastructural environments where infrastructural objects designed for pedestrians exist (e.g., overpasses, underpasses) [19–22]. Due to the aforementioned facts, it is necessary to understand the pedestrians' behaviour and devise measures that will control illegal behaviour.

Understanding modifiable determinants of pedestrians' willingness to illegally cross the road is a prerequisite for developing evidence-based interventions aimed at changing their behaviour. There have been a range of social–cognitive theoretical models that have been used to predict and explain behaviour on roads using different components of social influence and personal factors, such as the Health Belief Model (HBM), the Protective Motivation Theory (PMT), the Transtheoretical Model of Change (TMC), the Social Cognitive Theory (SCT), the Dual Process Theory (DPT), and the Theory of Planned Behaviour (TPB). Previous studies have shown that all theories were able to predict a significant portion of the variance of dangerous behaviour among road users; however, evidence from this study suggests that the TPB has superior predictive capacity compared to the other competing models [23–26].

1.2. Theory of Planned Behaviour (TPB)

For the purpose of establishing social influence and personal factors as predictors of human behaviour, the TPB is usually employed [27–29]. It represents the extension of the Theory of Reasoned Actions (TRA) [30]. The TPB is based on the assumption that some conscious reasoning is included in the formation of intentions to perform certain actions and that those actions are partially under the control of an individual. According to this theory, behaviour is predicted through intentions using attitudinal factors, normative factors, and perceived behavioural control (PBC). Attitudes reflect the evaluation of behaviour and its consequences, i.e., the evaluation of participation in the behaviour in question. Studies distinguish two main attitudinal components: cognitive and affective [31–34]. Cognitive attitudes represent the central component of the traditional TPB model regarding understanding and prediction of various health behaviours [35]. Subjective norms can be defined as observed social pressure from people that is important for an individual to perform or not perform a certain behaviour, i.e., an individual's perception of the degree to which other people approve or oppose the behaviour in question. Subjective norms motivate behaviour by asserting potential social reward or disapproval of participation or non-participation in that behaviour [36]. Perceived behavioural control reflects the extent to which an individual feels able to perform a certain behaviour or the perceived degree of control or confidence that an individual has over performing the behaviour in question [27]. A higher degree of perceived behavioural control of positive behaviour will usually be connected with a stronger intention to perform that behaviour. The research on intention in relation to certain traffic offences confirms that the smaller degree of perceived behavioural control when it comes to opting for high-risk behaviour (e.g., speeding) is related to a higher intention to exert behaviour, which is considered [37–41].

1.3. Extended Theoretical Framework of the TPB

In previous research, the TPB has been commonly used to explain pedestrian red light crossing behaviour, and useful conclusions have been drawn [12,13,40,42–45]. For example, Suo and Zhang [44] have analysed the discrepancies between the students at universities and their peers regarding the values in the basic components of the TPB. They revealed that academic students showed more favourable attitudes and self-restraint towards unsafe crossing practices in comparison with their peers. Similar results were observed by Xiao et al. [45], who have indicated that the original TPB could help explain the illegal road crossing behaviour of young pedestrians. They have demonstrated that attitudes, subjective norms, and PBC could be accurate predictors of pedestrians' intentions to violate traffic rules. However, although TPB components describe a considerable part of the variability in dependent variables, a certain part of the variability is not explained and cannot be attributed to measurement errors [33,34,36,39,41,46,47]. Thus, it is necessary to consider additional independent variables that would account for a significant part of the unexplained variability. In light of these considerations, Zhou and collaborators [43] have proposed the extension of the TPB by including three additional factors: descriptive norm, perceived risk, and conformity tendency, to assess their potential influence on the pedestrians' intention to cross the road against the light signal. The findings from this study confirmed the better predictive performance of the extended TPB model against the standard TPB model and highlighted that cognitive attitude, descriptive norm, and conformity tendency were significant predictors of the pedestrians' unsafe crossing intention. Furthermore, numerous recent studies have supported an extended theoretical framework of the TPB to explain risky behaviour among road users [38–41,46,47].

Descriptive norms reflect an individual's opinion of other people's behaviour [39], i.e., an individual's perception of the degree to which other people exert certain behaviours. The perception of what most people do influences an individual to act similarly; if the majority of people behave in a certain manner, then this behaviour is reasonable to the individual in question. Descriptive norms describe what is typical or normal and motivate behaviour by providing evidence for what is probably effective, adaptive, and proper behaviour [36]. Previous research has shown that the descriptive norm seemed to have better predictive ability than the subjective norm [42,43]. For example, Zhou et al. [43] argued that paying attention to how others behave while crossing a street will shape the pedestrians' motive to imitate (un)safe crossing behaviour.

Personal norms reflect the perception of moral correctness and an individual's sense of guilt in relation to certain behaviours. Moral norms and anticipated regret are different aspects of an individual's personal norms [38]. Moreover, the combination of the two sub-factors represents the factor of personal norms [46,47]. Moral norms describe an individual's internal moral rules [38,48], while anticipated regret is the expected affective consequences of violating these norms [38]. There is a clear assumption that if individuals perceive committing traffic offences as morally wrong and anticipate a large degree of regret for making these violations, their intention is lower. Previous investigations have confirmed a relationship between the moral norm, anticipated affect, and pedestrians' road crossing intention [13,42].

Normative norms represent a kind of conformity and can be defined as a tendency towards following the behaviour of others with the purpose of gaining benefits or avoiding unwanted conflict [42,46]. When engaging in traffic, pedestrians interact with other road users and observe their behaviour, taking into consideration and often acting in line with that behaviour [42]. This becomes relevant when pedestrians in a group tend to cross the road. In these circumstances, they feel a greater necessity for normative conformity (i.e., situational pressure) and behave in accordance with other pedestrians' decisions [42,43].

Habits are usually interpreted as a learned series of actions that become an automatic response to a specific situation [49], wherein the repetition of behaviour does not depend on conscious intentions to repeat such behaviour but on stimuli from the environment [50]. Because the repeated performance of behaviour precedes and results in automatism, as well as learned automatic responses that do not need to be frequently performed, habits can be conceptualized as context-dependent automaticity [51]. Xu et al. [40] have argued that pedestrians' willingness to illegally cross the road depends more on automatic than conscious cognitive processes.

1.4. Present Study

To the best of our knowledge, there are only a limited number of studies dealing with pedestrians' intention to cross on a red light signal that also use the abovementioned constructs within the extended TPB framework. Likewise, minimal focus has been given to the reliability and validity of these variations, as well as the predictive validity of hierarchical constructs. Finally, the personal norm and habit as automatic processes have not been used to explore the pedestrians' intention to violate within the TPB approach.

The primary research goal is to develop valid and reliable scales for every construct model that conceptually represents the extension of the TPB. The secondary goal is to examine the contribution of traditional components of the TPB (attitudes, subjective norms, and perceived behavioural control) in the prediction of pedestrians' intentions to cross on a red light, as well as some additional predictors that might significantly contribute to the predictive capability of the model.

2. Materials and Methods

2.1. Participants and Procedure

Data collection was based on a quota sample according to gender and age, representative of the population of the City of Novi Sad. A total of 700 questionnaires were distributed by post, after which 383 usable questionnaires were obtained and used in further analysis (55% response rate). A prepaid envelope was included for returning the completed questionnaire. The sample consists of 44% male and 56% female respondents. The age of the participants ranged from 18 to 90 (M = 42.9, SD = 16.3). Table 1 shows the structure of the sample compared to the population of Novi Sad. The sample is slightly biased towards female and younger individuals.

Table 1. Composition of the sample.

Criterion	Percentage of Sample	Percentage of Population
Gender		
Male	43.6	46.5
Female	56.4	53.5
Age		
18–24	12.0	11.2
25–34	24.8	18.5
35–44	22.2	18.0
45–54	17.8	20.9
55–64	8.6	14.0
65+	14.6	17.4

The respondents were instructed to carefully read all the questions and to reply truthfully so that research could provide qualitative results. In addition, they were assured that their answers would be treated anonymously and confidentially and that their data would be used exclusively for scientific purposes. The respondents were not required to provide personal information in order to reduce the possibility of them giving socially desirable answers. The study received ethical approval from the University of Montenegro.

2.2. Questionnaire Measures

In accordance with the theoretical concept of the TPB, items from previous research were used; however, for those items to be in line with the subject of the research, they were adapted to some extent [12,13,38,40,42,46,47,51–53]. The initial list of items was made and tested by experts on traffic safety from the University of Novi Sad. In their opinion, certain items were predefined or removed from the questionnaire (e.g., items that were very similar). Afterwards, a pilot study, including 154 students and employees at the University of Novi Sad, was carried out to ensure the clarity of each question and the acceptability of the questionnaire's format. The final questionnaire was designed, and all items were randomized. At the beginning of the study, before filling in the questionnaire, respondents were instructed to read the scenario, which was used to comply with the principle of compatibility [30]: "Imagine a situation in which, while walking, you want to go across the street. At the location where you want to cross the street, there is a traffic light, and it is showing a red light for pedestrians.".

2.2.1. Behavioural Intention

The intention to violate was measured by five questions. The first question observes the frequency with which the participant would cross on a red light signal within the next two weeks. Responses were rated on a 7-point Likert scale from 1 (never) to 7 (always). The second question measures the intention using the probability of crossing on a red light signal within the next two weeks. The respondents ranked their responses on a 7-point Likert scale from 1 (very improbable) to 7 (very probable). The remaining three questions are related to certain statements ranked on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) (e.g., "I think that in the future I will cross the road when a 'Don't walk' signal is on.").

2.2.2. Cognitive Attitude

Cognitive attitudes were measured directly by three items, to which respondents gave their opinions on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) (e.g., "Crossing on a 'Don't walk' signal is reckless.").

2.2.3. Affective Attitude

Affective attitudes towards respecting the red light signal for pedestrians were measured by three items (e.g., "Respecting a 'Don't walk' signal makes me nervous."). Every question was ranked on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.2.4. Subjective Norm

The construct of subjective norms was measured by five items that take into consideration groups of people or individuals who are important to respondents (e.g., "My best friends think that I should cross on a 'Don't walk' signal."). The respondents ranked their answers on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.2.5. Perceived Behavioural Control

Perceived behavioural control was measured by four items (e.g., "How easy or difficult would it be for you to respect the 'Don't walk' signal when there are no vehicles in the vicinity?"). The respondents ranked their answers on a 7-point Likert scale ranging from 1 (very difficult) to 7 (very easy).

2.2.6. Descriptive Norm

Descriptive norms were measured by three items (e.g., "How often do your best friends cross on a 'Don't walk' signal?"). The respondents ranked their answers on a 7-point Likert scale from 1 (never) to 7 (always). One item was ranked on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) (i.e., "Most people in your city do not comply with the 'Don't walk' signal.").

2.2.7. Normative Norm

The construct of normative norms was measured by four items (e.g., "I cross the road on a 'Don't walk' signal when I see other pedestrians doing it."). The participants ranked their responses on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.2.8. Personal Norm

Personal norms were assessed by five items (e.g., "I would feel guilty if I crossed on a 'Don't walk' signal."). Each statement was ranked on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.2.9. Habit

Habit measurement was assessed using a four-item automaticity subscale (Self-Report Behavioural Automaticity Index—SRBAI), as suggested by Gardner et al. [51]. Questionnaire items are defined in accordance with the research subject (e.g., "Crossing on a 'Don't walk' signal is something I do automatically."). Each item was ranked by respondents on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.3. Statistical Analyses

The data analyses were conducted in four phases. First, the initial data evaluation was performed with the purpose of determining the missing data, assessing normality, and testing susceptibility to extreme points using the IBM SPSS Statistics v.22 program. Furthermore, descriptive statistics (i.e., arithmetical means, dispersion, measures of skewness and kurtosis, etc.) were utilised to analyse the dataset. The data suitability was estimated by measures of the asymmetry (i.e., skewness) and the sharpness (i.e., kurtosis). If these measures are approximately close to 0, there is sufficient evidence to conclude that data are normally distributed [54]. Next, the underlying structure of scales was estimated by means of principal component analysis (PCA). Finally, hierarchical regression analysis was employed for the examination of the predictive validity of the TPB model.

3. Results

In order to determine the convergent and discriminant validity of the questionnaire, PCA was conducted on 37 items with an oblique (correlated) Promax rotation. The Kaiser–Meyer–Olkin value verified the adequacy of the sample size for the analysis (KMO = 0.87), and all KMO values for individual variables were higher than 0.68, which is good because the lower acceptable limit is 0.50 [55]. Bartlett's test of sphericity, χ^2 (666) = 5825.99, p = 0.001, pointed to a high enough correlation between items for PCA. The initial analysis was run with the aim of obtaining eigenvalues for every component in the data. If the sample size includes more than 250 respondents and the average of the communalities is higher than 0.60, Kaiser's criterion represents a reliable criterion for factor selection [55]. This condition was fulfilled, and nine factors had a suitable eigenvalue, which according to Kaiser's criterion needs to be higher than one. These factors explained 62.81% of the shared variance. All nine factors were in accordance with the theoretical assumptions. These nine factors were named Subjective norm (SN), Personal norm (PN), Normative norm (NN), Perceived behavioural control (PBC), Habit (Hbt), Intention (Int), Descriptive norm (DN), Cognitive attitude (CA), and Affective attitude (AA), based on the items that group around the same component (Table 2).

Table 2. Summary of exploratory results of factor analysis for dimensions of the extended TPB model (n = 383).

Item	Rotated Factor Loadings								
	SN	**PN**	**NN**	**PBC**	**Hbt**	**Int**	**DN**	**CA**	**AA**
Respecting a 'Don't walk' signal makes me nervous.	−0.068	0.144	0.012	−0.083	0.097	0.098	0.048	−0.210	0.652
Respecting a 'Don't walk' signal is monotonous.	−0.005	−0.150	−0.087	0.003	−0.044	−0.166	−0.035	0.035	0.885
Respecting a 'Don't walk' signal irritates me.	−0.015	0.103	0.035	−0.024	0.057	0.035	−0.003	−0.055	0.788
Crossing on a 'Don't walk' signal is reckless.	0.034	0.043	−0.077	0.059	0.056	0.136	−0.030	0.826	−0.085
Crossing on a 'Don't walk' signal is dangerous, even when it's done carefully.	−0.026	−0.011	0.042	−0.077	−0.017	−0.072	0.043	0.846	−0.042
Crossing on a 'Don't walk' signal increases the risk of partaking in a road accident.	−0.004	0.066	−0.003	−0.008	0.033	0.071	0.028	0.855	−0.020

Table 2. *Cont.*

Item	Rotated Factor Loadings								
	SN	PN	NN	PBC	Hbt	Int	DN	CA	AA
My best friends think that I should cross on a 'Don't walk' signal.	0.727	0.031	0.021	−0.119	−0.119	0.004	0.084	−0.043	0.011
My classmates/colleagues think that I should cross on a 'Don't walk' signal.	0.843	−0.050	−0.039	0.021	0.008	−0.066	0.040	−0.037	0.020
My partner/spouse thinks that I should cross on a 'Don't walk' signal.	0.591	0.091	−0.165	0.108	0.305	0.153	0.028	−0.026	0.025
My parents/children think that I should cross on a 'Don't walk' signal.	0.685	−0.014	0.096	0.018	0.011	0.118	−0.125	0.040	−0.160
Most people that are important to me think that I should cross on a 'Don't walk' signal.	0.863	−0.058	0.153	−0.045	−0.052	−0.244	0.018	0.061	0.031
How often do your best friends cross on a 'Don't walk' signal?	0.080	−0.016	−0.071	−0.024	−0.045	0.147	0.797	−0.075	−0.103
How often do your classmates/colleagues cross on a 'Don't walk' signal?	0.023	−0.055	−0.033	0.036	−0.021	0.139	0.827	−0.079	−0.094
How often do other pedestrians cross on a 'Don't walk' signal?	−0.053	0.035	−0.072	0.062	−0.029	−0.036	0.820	0.086	0.064
Most people in your city do not comply with the 'Don't walk' signal.	0.005	0.034	0.167	0.001	0.098	−0.312	0.609	0.137	0.140
If I crossed on a 'Don't walk' signal, I would regret it afterwards.	−0.111	0.791	0.180	−0.083	−0.117	−0.020	0.072	−0.006	−0.049
I would feel guilty if I crossed on a 'Don't walk' signal.	−0.018	0.777	−0.094	0.015	0.108	−0.001	0.003	−0.073	−0.009
Crossing on a 'Don't walk' signal violates my principles.	0.108	0.716	−0.169	−0.010	−0.013	0.029	−0.091	0.098	0.084
I would feel really bad if I crossed on a 'Don't walk' signal.	0.014	0.571	−0.041	−0.039	−0.025	−0.130	0.024	0.190	−0.069
I have a strong personal obligation not to cross on a 'Don't walk' signal.	−0.041	0.522	0.144	0.183	−0.068	−0.133	−0.017	0.024	0.078
It is more important to cross the road when other pedestrians do it than to respect a 'Don't walk' signal.	0.025	0.148	0.722	−0.077	0.071	0.142	−0.016	−0.111	−0.177
I cross the road on a 'Don't walk' signal when I see other pedestrians doing it.	0.014	−0.094	0.687	0.099	0.005	0.146	−0.086	0.068	0.138
When a 'Don't walk' signal is on, I often rely on other pedestrians' choices, and I act as they do.	−0.007	−0.077	0.718	0.026	0.093	−0.030	0.062	0.055	0.039
Usually, when a 'Don't walk' signal is on, pedestrians around me are the ones who decide if we are going to cross or not.	0.084	0.012	0.838	0.027	−0.039	−0.039	−0.038	−0.039	−0.036
Crossing on a 'Don't walk' signal is something I do automatically.	0.180	0.003	0.016	0.040	0.476	0.070	−0.057	0.024	0.114
Crossing on a 'Don't walk' signal is something I do without consciously remembering doing so.	−0.048	−0.056	−0.007	−0.021	0.807	0.014	0.001	0.056	0.064
Crossing on a 'Don't walk' signal is something I do without thinking.	−0.038	−0.080	0.051	−0.082	0.862	−0.179	−0.014	0.033	−0.040
Crossing on a 'Don't walk' signal is something I start doing before I realize I'm doing it.	−0.009	0.083	0.058	0.056	0.697	0.175	0.018	−0.035	−0.021
How easy or difficult would it be for you to respect a 'Don't walk' signal when you are in a hurry?	−0.015	0.058	−0.011	0.769	0.101	−0.058	0.084	−0.087	−0.061
How easy or difficult would it be for you to respect a 'Don't walk' signal when there are no vehicles in the vicinity?	−0.146	−0.023	0.148	0.749	0.049	−0.087	0.016	0.020	−0.037
How easy or difficult would it be for you to respect a 'Don't walk' signal when you are excited or nervous?	0.065	0.018	−0.099	0.792	−0.186	0.141	−0.075	0.076	0.133
How easy or difficult would it be for you to respect a 'Don't walk' signal when the weather is bad (rain, snow, etc.)?	0.035	−0.046	0.022	0.749	−0.022	−0.051	0.055	−0.029	−0.105
How often, in the next two weeks, do you intend to cross the road on a 'Don't walk' signal?	−0.009	−0.041	0.149	−0.050	0.016	0.592	0.112	0.044	0.106
I will try not to cross the road on a 'Don't walk' signal in the future. (reverse coded)	−0.027	0.036	0.013	0.017	0.035	0.794	−0.078	−0.090	−0.275
I think that in the future I will cross the road when a 'Don't walk' signal is on.	0.107	0.016	0.127	0.074	−0.130	0.630	−0.006	0.025	0.236

Table 2. *Cont.*

Item	Rotated Factor Loadings								
	SN	PN	NN	PBC	Hbt	Int	DN	CA	AA
My intention of not crossing the road on a 'Don't walk' signal in the future is high. (reverse coded)	−0.143	−0.168	−0.077	0.004	0.054	0.789	0.021	0.150	0.037
During the following two weeks, how probable is it that you will cross the road on a 'Don't walk' signal?	0.015	−0.048	0.093	−0.166	−0.059	0.633	0.050	0.082	0.060
Eigenvalues	8.83	3.02	2.30	2.20	1.83	1.43	1.38	1.22	1.03
% of variance	23.86	8.18	6.22	5.95	4.95	3.87	3.72	3.29	2.77
Cronbach's alpha	0.815	0.783	0.808	0.785	0.760	0.803	0.763	0.804	0.722

Note: Factor loadings over 0.40 appear in bold. SN = Subjective norm; PN = Personal norm; NN = Normative norm; PBC = Perceived behavioural control; Hbt = Habit; Int = Intention; DN = Descriptive norm; CA = Cognitive attitude; AA = Affective attitude.

In addition to inspecting the validity and separating certain constructs, the internal consistency and reliability of the questionnaire were examined. All components have a Cronbach's alpha coefficient of reliability of $\alpha > 0.7$, which indicates an adequate measure of the reliability of these scales [56] (Table 2).

The means, standard deviations, and zero-order correlations between model constructs are presented in Table 3. Descriptive statistics of the basic TPB components suggest that pedestrians generally have negative attitudes towards jaywalking, are aware that they will face disapproval from other people for committing such an offence, and that respecting the red light signal is easy. In terms of additional predictors, general descriptive statistics indicate a positive affective attitude with regard to respecting red light signals for pedestrians. Descriptive norms indicate that respondents believe that other pedestrians commit offences. Normative norms indicate that pedestrians do not follow the behaviour of other pedestrians, while personal norms suggest that pedestrians think that such an offence is morally wrong and would feel guilty for committing it. Typically, respondents stated they do not violate automatically, i.e., for the sake of habits. The mean value of the intention to commit an offence was below the midpoint scale (see Table 3).

Table 3. Descriptive statistics and zero-order correlations between model constructs.

	M	*SD*	CA	SN	PBC	AA	DN	NN	PN	Hbt	Int
CA	5.79	1.41	-								
SN	1.92	1.02	−0.25 **	-							
PBC	4.15	1.51	0.17 **	−0.09	-						
AA	3.00	1.51	−0.11 *	0.26 **	−0.21 **	-					
DN	3.96	1.28	0.01	0.32 **	−0.04	0.16 **	-				
NN	2.08	1.13	−0.19 **	0.37 **	−0.20 **	0.37 **	0.16 **	-			
PN	4.36	1.49	0.30 **	−0.19 **	0.29 **	−0.35 **	−0.16 **	−0.28 **	-		
Hbt	2.31	1.33	−0.17 **	0.31 **	−0.16 **	0.35 **	0.16 **	0.44 **	−0.19 **	-	
Int	2.27	1.12	−0.32 **	0.44 **	−0.29 **	0.43 **	0.23 **	0.46 **	−0.50 **	0.42 **	-

Note: * $p = 0.05$; ** $p = 0.01$. SN = Subjective norm; PN = Personal norm; NN = Normative norm; PBC = Perceived behavioural control; Hbt = Habit; Int = Intention; DN = Descriptive norm; CA = Cognitive attitude; AA = Affective attitude.

All predictors were significantly correlated with the intention to violate. According to Cohen's [57] guidelines, the magnitude of effect sizes ranged from small to large. Personal norms were most strongly related to intention (Table 3).

A six-step multiple regression analysis was conducted in order to predict pedestrians' intention to cross the road during a red-light phase. Overall, the model accounts for 49% of variances in pedestrians' intentions to commit the offence in question. First, the basic components of the TPB, i.e., cognitive attitudes, subjective norms, and perceived behavioural control, were introduced. These components were statistically significant predictors and accounted for 29% of the variance in the intention to violate. Second, affective attitudes were introduced (β = 0.30, $p = 0.01$), which accounted for an 8% increase in variance. Third, descriptive norms were introduced (β = 0.09, $p = 0.05$), which accounted for a 1% increase in variance. When normative norms were introduced in the fourth step (β = 0.22, $p = 0.01$), the explained variance increased by 3%. The results of the fifth step show that personal norms have a statistically significant influence on intention and account for an additional 6% of variance (β = −0.28, $p = 0.01$). The last step involved the introduction of habits (β = 0.15, $p = 0.01$), which accounted for a 2% increase in variance. In the fifth and sixth steps, descriptive norms were not statistically significant predictors of intention, $p > 0.05$ (Table 4).

Table 4. Summary of hierarchical regression analysis for variables predicting intention to violate.

	Predictor	β (Step 1)	β (Step 2)	β (Step 3)	β (Step 4)	β (Step5)	β (Step 6)
TPB components	CA	−0.19 **	−0.19 **	−0.20 **	−0.18 **	−0.12 **	−0.11 **
	SN	0.37 **	0.30 **	0.27 **	0.22 **	0.22 **	0.21 **
	PBC	−0.22 **	−0.16 **	−0.16 **	−0.14 **	−0.09 *	−0.08 *
Additional components	AA		0.30 **	0.29 **	0.23 **	0.16 **	0.14 **
	DN			0.09 *	0.09 *	0.06	0.05
	NN				0.22 **	0.19 **	0.15 **
	PN					−0.28 **	−0.28 **
	Hbt						0.15 **
R^2		0.29	0.37	0.38	0.41	0.47	0.49
R^2 adjusted		0.28	0.36	0.37	0.40	0.46	0.47
ΔR^2		0.29 **	0.08 **	0.01 *	0.03 **	0.06 **	0.02 **

Note: * $p = 0.05$; ** $p = 0.01$. SN = Subjective norm; PN = Personal norm; NN = Normative norm; PBC = Perceived behavioural control; Hbt = Habit; Int = Intention; DN = Descriptive norm; CA = Cognitive attitude; AA = Affective attitude.

A relative importance weights analysis is used with the purpose of determining the relative effect of every predictor, which enables more accurate variance partitioning among correlated predictors [58,59]. Due to the limited possibilities of standardised regression coefficients or zero-order correlations for determining variable importance when the predictors are correlated, relative weights analysis was applied. Relative weights analysis was conducted using the procedure recommended by Tonidandel and LeBreton [59]. Table 5 shows all values of relative weights and the percentage of RW variables used with the purpose of predicting pedestrians' intentions to violate. The results show that the highest percentage of variables in intentions was explained by personal norms (24.6%), followed by subjective norms (16.7%), normative norms (14.6%), affective attitudes (13.3%), and habits (12.8%).

Table 5. Relative importance weights of predictors in predicting violation intention.

	RW	Percentage
Personal norm	0.12	24.6
Subjective norm	0.08	16.7
Normative norm	0.07	14.6
Affective attitude	0.06	13.3
Habit	0.06	12.8
Cognitive attitude	0.04	8.3
Perceived behavioural control	0.03	6.0
Descriptive norm	0.02	3.8

4. Discussion

The aim of this research involves two aspects. First, the research is exploratory because it is aimed at developing a valid and reliable questionnaire to measure the determinants of pedestrians' intention to violate, based on the theory of planned behaviour. Second, the aim was to test the predictive validity of an extended theoretical framework of the TPB in relation to pedestrians' intentions to violate.

A principle component analysis was carried out on the entire set of items, which allowed the extraction of the underlying dimensions of the extended TPB. Nine factors are singled out, which, based on the theoretical concept, were expected to be found. These factors include independent predictors of the standard TPB concept (i.e., cognitive attitude, subjective norm, and perceived behavioural control), additional independent predictors (i.e., affective attitude, personal norms, descriptive norms, normative norms, and habits), and the intention to violate as a response variable. The analysis showed adequate internal consistency and reliability of the questionnaire.

Overall, the results provide significant support for the concept of the extended theoretical framework of the TPB, whose predictors statistically significantly explain 49% of the variance in pedestrians' intentions to violate traffic rules. In accordance with the assumptions, the TPB constructs, on their own, account for the largest part of the variance with regard to pedestrians' intention to violate traffic rules, which is consistent with previous research on adult pedestrians' intentions [12,40,42,60] and adolescent pedestrians' intentions [13,61] to commit illegal road crossing.

Pedestrians who have positive cognitive attitudes towards jaywalking were more likely to report a stronger intention to violate. Cognitive attitudes are a statistically significant predictor of pedestrians' intentions to commit the offence. However, when you take into account their relative effect on intention, they are minor compared to other predictors. The findings in this research indicate that cognitive and affective attitudes show discriminant validity and differential predictive ability. Relative importance analysis indicated that affective attitudes make a larger contribution than cognitive attitudes to pedestrians' intention to commit an offence. Affective attitude towards respecting a 'Don't walk' signal was a significant independent predictor of pedestrians' intention to violate, even after controlling for the effects of the other predictors. Trafimow et al. [62] found that for many behaviours, the influence of affective responses on behavioural intention is greater than cognitive. Loewenstein et al. [63] have argued that in the event of a discrepancy between cognitive and affective responses, it is more likely that the latter drives behaviour. Lawton et al. [32] found that for high-risk behaviours, affective beliefs could have a more significant role in predicting future engagement in behaviour in relation to cognitive beliefs. In studies that deal with the risky behaviour of pedestrians [13,40], there was a lack of relationship between cognitive attitudes and behavioural intention, which offers growing evidence for the role of affective attitudes.

Perceived behavioural control is a statistically significant predictor of the intention of pedestrians to cross the road illegally during a red-light phase. Pedestrians who have less control over their behaviour reported a stronger intention to commit the offence. This research indicates that perceived behavioural control has a higher relative weight only in comparison to descriptive norms. This is not consistent with other studies in which perceived behavioural control is one of the most important predictors of pedestrians' intention to commit an offence [12,13,40,42,61].

When examining normative influence on behaviour, it is important to distinguish between the 'is' (descriptive) and the 'ought to' (injunctive) meanings of social norms [64], because they reflect two different sources of motivation [65]. This study confirms that subjective and descriptive norms represent two different constructs and have different predictive abilities. Subjective norms represent a statistically significant predictor of pedestrians' intention to commit the offence. Pedestrians who perceive less social pressure in terms of committing illegal crossing during the red signal for pedestrians reported a stronger intention to commit this offence in the future. If we consider their relative weight on intention, then subjective norms act as the second major predictor after personal norms. The importance of subjective norms as predictors was recorded in other studies that considered pedestrians' intentions to commit the offence [13,40,42,60,61]. Descriptive norms represent the least important predictor of intention to commit the offence, as they describe only one percent of the variance. With the introduction of personal norms in the fifth step of the hierarchical regression, descriptive norms have lost their statistical significance. This means that despite the fact that descriptive norms are singled out as a separate construct, their predictive ability is limited. The role of descriptive norms is not consistent with research in other areas, as the results indicate that descriptive norms are a stronger predictor of intention than subjective norms [66].

Pedestrians who commit illegal road crossings in a group feel that the responsibility for the violation of regulations is divided among other participants in the group, which encourages every pedestrian to ignore the consequences of this behaviour [14]. The findings are in favour of this fact as well. Pedestrians who have demonstrated a higher degree of conformity with other pedestrians more often reported the intention to commit the offence in the future. The findings also support previous findings that pedestrians reported a greater likelihood of committing illegal road crossings when other pedestrians do so [42,61]. Normative norms are the third most important predictor of pedestrians' intention to commit the offence, after personal and subjective norms.

Pedestrians who expressed a greater degree of moral responsibility and regret had a less frequent intention to commit illegal road crossings. The present research suggests that personal norms have the biggest independent effect on pedestrians' intentions to commit the offence. For pedestrians' intention to violate, the additional variance accounted for by personal norm was 6%, which is consistent with research findings of pedestrians' illegal behaviour [13,40]. In addition, findings from other studies indicate that other social behaviours support the importance of personal norms [38,52,67]. Personal norms may reflect aspects of attitudes towards behaviour, as anticipated affective emotions and moral norms can be perceived as a consequence of the behaviour in question [38]. Godin et al. [68] noted in their study that individuals whose intention was largely based on moral norms have a higher probability of performing respectful, healthy behaviours than individuals whose intention was based on attitudes.

The present findings suggest that the intention to commit illegal pedestrian road crossings is largely influenced by social factors (subjective, normative, descriptive, and personal norms) rather than by personal considerations (attitudes and perceived behavioural control).

The current study indicates that habits represent a statistically significant predictor of intention to commit the offence after controlling for the variables already included in the TPB model. Pedestrians who have a stronger habit reported a higher tendency to commit illegal road crossings during the red-light phase. Habits explained only 2% of the variance in pedestrians' intention to commit the offence, which is not in accordance with the results of other studies on traffic offences [39,46,47] and violations committed by pedestrians [40]. Habits were statistically significantly correlated with other predictors, and therefore their contribution was examined, which proportionally makes up R^2. The results of the relative importance analysis show that habits are one of the major predictors after personal norms, subjective norms, normative norms, and affective attitudes. In this work, habits are based on behavioural automaticity, in contrast to the traditional approach, which measures habits as past behavioural frequency. The consideration of habits as past behavioural frequency can have certain drawbacks [25,48,67,69,70], which can manifest through inflated habit–behaviour associations [71].

5. Conclusions

In conclusion, the theoretical and practical application of the extended TPB model was considered. From a theoretical point of view, the present study confirmed that the extended TPB model could be successfully used to explain unsafe pedestrian behaviours and recognise factors to target road safety countermeasures and strategies. From a practical standpoint, the results of this research can be useful for creating traffic safety programmes and action plans aimed at reducing pedestrian fatalities. The results indicate that social norms, affective attitudes, and habits should form the basis for creating traffic safety interventions related to pedestrians illegally crossing roads during red pedestrian signals at traffic lights. Since these social factors are independent predictors of the pedestrians' intentions regarding the mentioned behaviour, improving these components can also improve pedestrian behaviour. For example, measures based on personal norms should highlight messages containing a sense of guilt for committing offences by pedestrians. In addition to campaigns, changing personal norms or moral standards can be achieved through educational programmes and courses. Also, pedestrians who commit offences will not change their attitudes or behaviour unless they notice that other pedestrians are following the rules. Therefore, it is important to influence their perception of other pedestrians' behaviour in the situation under consideration. This can be achieved through campaigns. It is important to emphasise that messages targeting specific groups must be based on the aforementioned characteristics. In addition to campaigns to raise awareness and educational programmes and courses, it is necessary to improve the enforcement system to achieve the expected effects.

Future research should also focus on other risky behaviours, such as crossing roads at mid-block locations or outside of pedestrian crossings. Additionally, it is necessary to apply a confirmatory approach and/or use models that examine indirect links between components (i.e., structural equation modelling technique).

Despite the attempt to conduct methodologically accurate research, this study has certain limitations. First, the intention of pedestrians, whose relation to behaviour can be questionable, was taken into consideration as a dependent variable. Additionally, the research does not involve measurements of real behaviours. Therefore, the role of intention in the prediction of real behaviour can be ambiguous. Furthermore, the data presented in this study were based on self-descriptive techniques alone. Such a method of data collection can lead to distortions in the data because of socially desirable responses. Although the subjects were assured of the anonymity and confidentiality of their data, they may still have been reluctant to fully disclose personal information.

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