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Factors Influencing Young Drivers' Willingness to Engage in Risky Driving Behavior: Continuous Lane-Changing

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Abstract: Young adults have a tendency to drive unsafely and put themselves at a high level of risk. Continuous lane-changing is one such kind of risky behavior. This study aimed to investigate the factors that influence young drivers based on an integrated model of the prototype willingness model (PWM) and the theory of planned behavior (TPB). The validity of the model was evaluated by data collected from 481 young drivers through an online questionnaire. The structural equation model was used to test the proposed model, and the findings indicated that young drivers' willingness to engage in continuous lane-changing was influenced by attitude, subjective norms, perceived behavioral control, perceived risk, prototype similarity, and prototype favorability. The integrated model of PWM-TPB accounted for 58.3% of the variance in young drivers' willingness, and the findings possess implications for designing effective interventions.

Keywords: young drivers; continuous lane-changing; behavioral willingness; theory of planned behavior; prototype willingness model

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1. Introduction

Every year, road traffic accidents claim about 1.35 million lives worldwide, cause 20–50 million to be injured, and have become the number-one killer of young people [1]. In 2018 in China, 51.36 million young drivers (aged 18–25) constituted 12.56% of all drivers [2] and they accounted for approximately 39% of all driving-related crashes [3]. Young drivers have been receiving great attention from many researchers due to their risky driving such as speeding [4–7], driving while drowsy [8], texting while driving [9–12], drunk driving [13,14], smartphone use while driving [15], not wearing a seat belt [16], and so on. Researchers [17–21] have also developed a series of Young Drivers Scale (YDS) to measure risky driving behavior in different countries. In this study, we focused on a different risky driving behavior among young drivers: continuous lane-changing.

1.1. Continuous Lane-Changing Behavior

In 2012, risky lane-changing and merging caused about 347,000 vehicle collisions in the United States, accounting for 4% of all motor vehicle crashes [22]. In China, risky lane-changing, overtaking, and merging caused approximately 4.9% of road crashes in 2015 [23]. To get faster speed or better driving space on roads, some drivers choose to perform risky lane-changing in their daily driving. A driving study conducted in Shanghai, based on the collected daily data of 60 drivers, over 3 months demonstrated that Chinese drivers are aggressive and change lanes frequently [24–27]. The average frequency of lane-changing on urban expressways, urban arterial roads, freeways, and suburban arterial roads was 0.690, 0.820, 0.317, and 0.605 per kilometer, respectively [24]. A survey conducted among

Chinese drivers by Ma et al. [28] showed that 77.9% of young drivers reported that they changed lanes frequently and Wang et al. [29] reported they were more likely to cross solid lines near urban intersections.

According to the Regulations for the Implementation of the Law of China on Road Traffic Safety [30], lane-changing should not affect traffic flow in neighboring lanes. As shown in Figure 1a, when drivers change to a non-adjacent lane (from Lane 1 to 3), they should do so lane by lane. Drivers should first change lanes from Lane 1 to 2, and then they should drive in Lane 2 for a period of time to observe the driving conditions of vehicles behind in Lane 3 to ensure safety. Only on the premise of safety, drivers are allowed to continue to conduct lane-changing. As shown in Figure 1b, continuous lane-changing refers to performing a lane change directly to a non-adjacent lane without any required driving time in the second lane. It is likely to cause visual blind spots and lead to collisions when performing such continuous lane-changing.

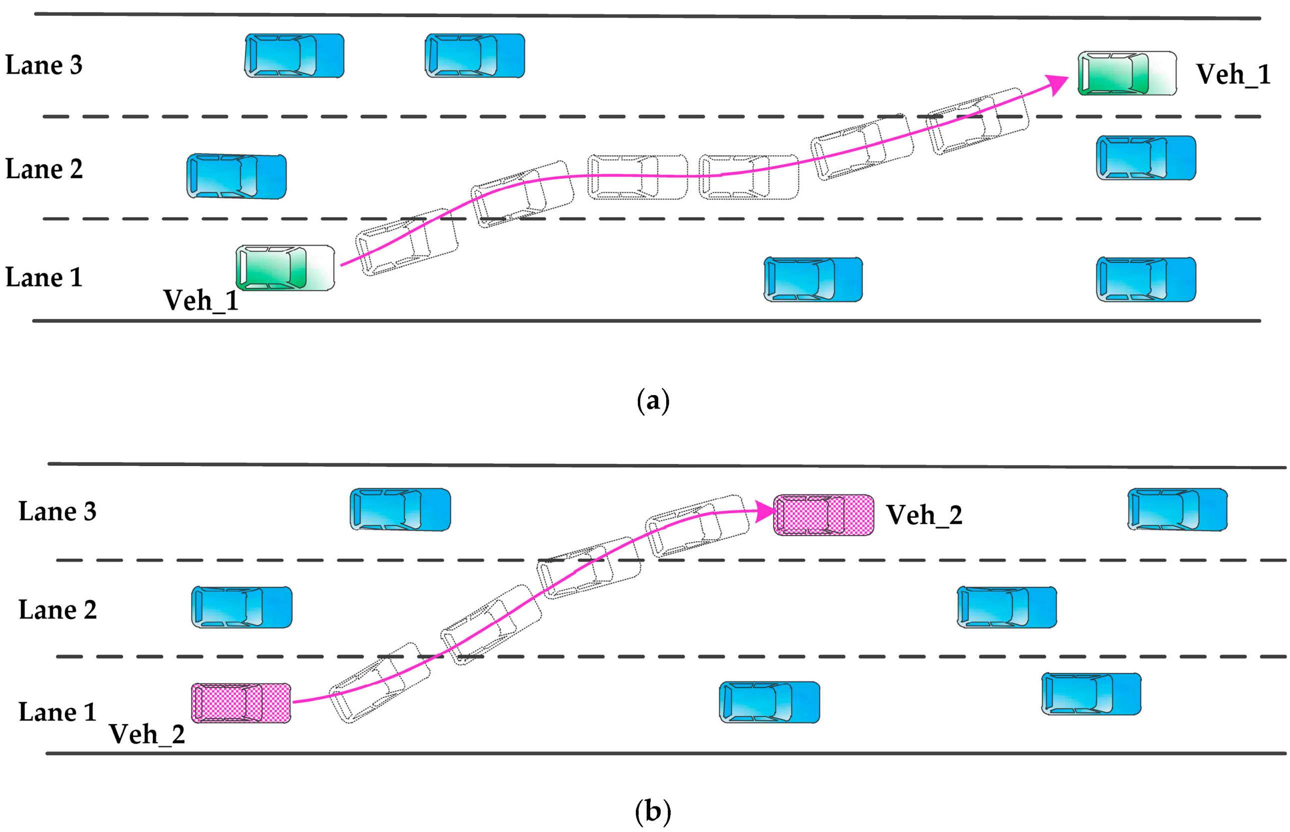

Figure 1. Schematic diagram of lane-changing scenarios, (**a**) normal lane-changing to a non-adjacent lane, (**b**) continuous lane-changing to a non-adjacent lane.

The frequency of continuous lane-changing in China is high. For example, on the Gonghexin Road (section near Guangzhongxi Road) in Shanghai from June to August in 2018, more than 1200 cases were captured by the newly installed special "electronic police" [31]. Meng et al. [32] reported that drivers conduct continuous lane-changing more frequently near both on- and off-ramps and accounted for about 35% of all traffic violations near these areas. Hao et al. [33] showed that drivers' frequent and continuous lane-changing accounted for approximately 24.25% of lane-changing violations near urban intersections, which had a high level of crash risk [34–37]. Thus, as a kind of risky driving behavior, continuous lane-changing should be focused on. However, to the best of our knowledge, no known studies have examined the influences underlying this behavior, especially among young drivers.

1.2. Potential Factors Influencing Young Drivers' Risky Driving

Traffic accident data analysis is an effective method for examining the factors that affect the occurrence and severity of traffic accidents as well as risky driving behavior [38,39]. A questionnaire survey, however, can also uncover the socio-psychological factors of young drivers, for this the prototype willingness model (PWM) and the theory of planned behavior (TPB) were widely used.

1.2.1. The PWM

The PWM is an improved theory that specifically targets a young age group based on analyzing reasoned-path and social-reactive-path decision-making [40–42]. For reasoned path, the intention is predicted by attitude and subjective norms. The social reactive path considers unplanned and unconscious decision-making based on behavioral willingness and prototype perceptions. Prototypes reflect the image of a typical person engaged in certain behavior. According to the PWM, there were two kinds of prototype perceptions: similarity and favorability [40]. In the social-reactive path, behavior is directly predicted by behavioral willingness and indirectly predicted by prototype similarity and favorability. Both intention and willingness predict behavior.

Many studies have used the PWM to explain traffic violations by pedestrians, cyclists, and drivers. Demir et al. [43] showed that pedestrian violations were mainly predicted by prototype perceptions, behavioral willingness, and perceived behavioral control (PBC). Tang et al. [44] examined the factors underlying electric bikers' red-light running, and the results showed that the PWM explained more than 80% of the variance. Elliott et al. [45] demonstrated that the PWM could explain 89% of the variance of speeding behavior, but behavioral willingness was a stronger predictor of speeding than intention. Basse et al. [46] confirmed the effectiveness of the PWM in explaining young passengers' willingness to speak up to a speeding driver.

For young drivers, Rivis et al. [14] reported that young male drivers' willingness toward drunk driving could be predicted by both TPB and PWM variables. Moreover, prototype similarity and prototype favorability accounted for 7% of the variance. Scott-Parker et al. [5], Forward [6], and Chaleshgar et al. [47] confirmed that the PWM model could effectively explain young drivers' self-reported speeding behavior. Harbeck et al. [48] showed that a higher risk of prototype favorability and similarity could predict higher self-reporting of risky driving behavior among young drivers. Preece et al. [49] examined the factors influencing young drivers' willingness to speed and text while driving based on the PWM, and the results showed that attitudes and prototype perception were significant predictors. In all cases, the aforementioned findings confirmed the high efficacy of the PWM in explaining some risky driving behaviors among young drivers.

Based on the PWM, a model (see Model 1 in Figure 2) was proposed to explain young drivers' behavioral willingness to engage in continuous lane-changing, and some hypotheses are shown as follows:

Hypothesis 1 (H1). *The attitudes of young drivers' continuous lane-changing have a significant influence on their behavioral willingness.*

Hypothesis 2 (H2). *The subjective norms of young drivers' continuous lane-changing have a significant influence on their behavioral willingness.*

Hypothesis 3 (H3). *The prototype similarity of young drivers' continuous lane-changing has a significant influence on their behavioral willingness.*

Hypothesis 4 (H4). *The prototype favorability of young drivers' continuous lane-changing has a significant influence on their behavioral willingness.*

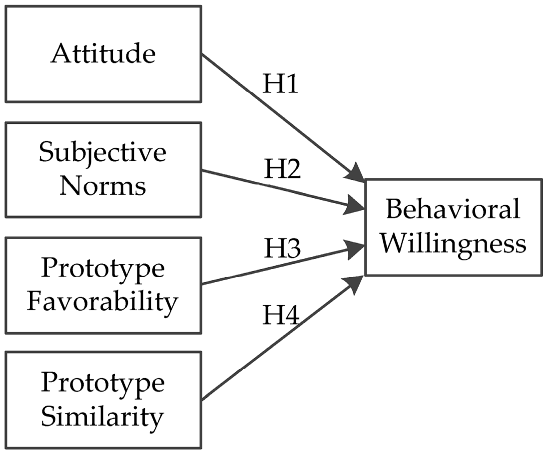

Figure 2. Model 1: A conceptual model based on the PWM.

1.2.2. The TPB and Additional Factors

According to the TPB [50,51], attitude, subjective norms, and PBC together influence one's behavioral intention and behavior [50,51]. PBC refers to a person's speculation and judgment about whether he or she has the ability to complete a certain behavior. PBC directly affects behavioral intention and behavior, and can indirectly affect behavior through intention. The TPB has been widely used to explain young drivers' risky and illegal driving in studies on traffic safety. Table 1 provides a summary of the TPB basic factors used.

Table 1. A summary of TPB basic factors used in young drivers' risky driving studies.

Behavior	Attitude (AT)	Subjective Norms (SN)	Perceived Behavioral Control (PBC)	Reference
Speeding	Y	Y	Y	[4]
	Y	Y	Y	[6]
	Y	Y	Y	[7]
Driving while drowsy	Y	Y	Y	[8]
Texting while driving	Y	N	N	[9]
	Y	Y	Y	[10]
	Y	Y [a]/N [b]	Y [a]/N [b]	[11]
Drunk driving	N	Y	N	[12]
	Y	Y	Y	[13]
	Y	Y	Y	[14]
Smartphone phone use while driving	Y	Y	Y	[15]

Note: Y: significant, N: non-significant; [a] Sending texts, [b] Reading texts.

In addition to the TPB basic factors, many studies enhanced the effectiveness of TPB predictions by introducing more constructs, and two were included in the current study: moral norms and perceived risk. Moral norms refer to a person's determination of whether to perform a certain behavior right or wrong based on social values [52]. Gauld et al. [10], Nemme et al. [11], and Benson et al. [53] showed that moral norms significantly influenced young people's intention to text while driving; Conner et al. [54] demonstrated that they could predict a driver' intention to speed; Moan and Rise [55] reported that they could explain a driver' intention not to drink and drive; and Wang and Xu [56] showed that moral norms significantly influenced a driver' willingness not to give space to ambulances. Based on the above studies, we hypothesized that moral norms could significantly predict young drivers' willingness for continuous lane-changing.

Perceived risk refers to one's perception of the risk associated with a certain behavior. Previous studies showed that it was significantly associated with speeding [7], driving while drowsy [8], driving while texting [9,57], driving while on the phone [58], and driving through flooded waterways [59]. There are two main risks for drivers: crash and apprehension [7,9,58]. On the one hand, continuous lane-changing may cause drivers to get involved in a traffic crash, and on the other hand, they may be pulled over by the police at places such as signalized intersections. Therefore, we hypothesized that perceived risk was also a significant predictor of young drivers' willingness toward continuous lane-changing.

Based on the above analysis, an extended TPB model (see Figure 3) was also proposed to explain young drivers' behavioral willingness to engage in continuous lane-changing, and some other hypotheses are shown as follows:

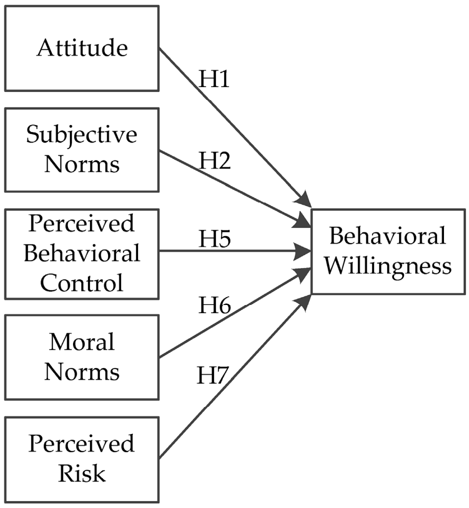

Figure 3. Model 2: An extended TPB model.

Hypothesis 5 (H5). *The PBC of young drivers' continuous lane-changing has a significant influence on their behavioral willingness.*

Hypothesis 6 (H6). *The moral norms of young drivers' continuous lane-changing have a significant influence on their behavioral willingness.*

Hypothesis 7 (H7). *The perceived risk of young drivers' continuous lane-changing has a significant influence on their behavioral willingness.*

1.3. Current Study

The factors underlying young drivers' continuous lane-changing are not clear, but it is evident that PWM and TPB constructs significantly relate to the willingness to engage in risky driving. Moreover, previous studies showed that integrating the PWM and TPB would enhance the explanatory efficiency of traffic violations [14,43,45,48]. Inspired by these studies, an integrated model of the PWM and TPB (Model 3) for this study was constructed as shown in Figure 4. According to the model, it was hypothesized that young drivers' willingness could be predicted by the PWM and TPB factors (attitude, subjective norms, prototype similarity, prototype favorability, and PBC), and two additional factors (moral norms and perceived risk). This study also examined to what extend the integrated model was able to explain why young drivers engaged in continuous lane-changing.

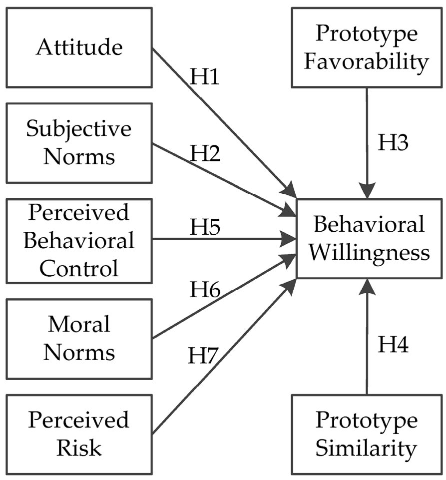

Figure 4. Model 3: An integrated model of the PWM and TPB.

2. Materials and Methods

2.1. Participants and Procedure

The sample for this study came from Pingdingshan city in Henan Province in China. By August 2020, it had about 143,027 young car drivers (67.1% males). Considering the high usage of chat software among young Chinese drivers, we recruited participants mainly through popular chat groups. In the recruitment information, it was stipulated that only people aged 18–25 with a driver's license could participate. Before the survey, participants were all informed of the purpose, the procedure, and the use of the survey. They participated voluntarily and could leave at any time. All information was kept strictly confidential. Since continuous lane-changing is illegal and dangerous, the participants were reminded of the dangers of this behavior and were instructed on how to perform a lane change correctly at the end of the questionnaire.

The survey was carried out from August 3 to 31, 2020. A total of 600 young drivers were invited, 515 of whom completed the online questionnaire. Of the answered questionnaires, 34 were excluded because the participants completed the survey in less than the minimum response time required, and the answers were unrealistic such as being too young to earn a degree, all answers being the same. In the end, 481 responses were valid.

2.2. Measures

The questionnaire was in Chinese and consisted of three parts. The first part introduced the background and purpose of the survey and the meaning of continuous lane-changing behavior. There were two questions at the beginning of the questionnaire: "Do you have a motor vehicle driving license?" and "Do you drive a car in your daily life?", and only those who answered "yes" to both questions were allowed to continue. The second part collected the participants' personal information and their continuous lane-changing experience over the past 3 months. The third part measured the indicator variables of the PWM and TPB. To enhance the response rate, we kept to a small number of items to measure the constructs of the PWM-TPB model. Table 2 shows the details of the items and the range of scales. Figure 5 presents the three driving scenarios used to measure participants' behavioral willingness in situations where they encountered opportunities to conduct continuous lane-changing.

Table 2. Constructs and items of the questionnaire.

Constructs	Items	Adapted Sources
AT	*1 = "strongly disagree" to 5 = "strongly agree"* AT1. Continuous lane-changing will save me time. AT2. Continuous lane-changing will enable me to reach my destination faster. AT3. Continuous lane-changing will not affect traffic order. AT4. Continuous lane-changing will give me a sense of success.	[10,11,15,51,54–60]
SN	*1 = "strongly disagree" to 5 = "strongly agree"* SN1. My parents think it is not okay to conduct continuous lane-changing. SN2. My friends think it is not okay to conduct continuous lane-changing. SN3. My parents would disapprove of my continuous lane-changing behavior. SN4. My friends would disapprove of my continuous lane-changing behavior.	[10,11,15,51,54–60]
PBC	*1 = "strongly disagree" to 5 = "strongly agree"* PBC1. I can evaluate all situations when I conduct continuous lane-changing. PBC2. I can respond quickly to all emergencies when I conduct continuous lane-changing. PBC3. I have confidence in my driving ability to conduct continuous lane-changing.	[10,11,15,51,54–60]
Moral Norms (MN)	*1 = "strongly disagree" to 5 = "strongly agree"* MN1. It is wrong for me to conduct continuous lane-changing. MN2. I will feel guilty if I conduct continuous lane-changing. MN3. Conducting continuous lane-changing goes against my principles.	[10,11,15,52–56]
Perceived Risk (PR)	*1 = "no extent at all" to 5 = "a great extent"* PR1. To what extent do you agree that it is likely you will have a crash if you conduct continuous lane-changing? PR2. To what extent do you agree that it is likely you will encounter an emergency if you conduct continuous lane-changing? PR3. To what extent do you agree that it is likely you will be caught by the police if you conduct continuous lane-changing? PR4. To what extent do you agree that it is likely you will be fined by the police if you conduct continuous lane-changing?	[7–9,57–59]
Prototype Similarity (PS)	PS1. Do the characteristics that describe the type of drivers your age who regularly conduct continuous lane-changing also describe you? (*1 = definitely no to 5 = definitely yes*) PS2. How similar are you to the type of drivers your age who regularly conduct continuous lane-changing? (*1 = not at all similar to 5 = very similar*) PS3. I am comparable to the typical person my age who regularly conducts continuous lane-changing. (*1 = strongly disagree to 5 = strongly agree*) PS4. To what extent are you like the typical driver your age who regularly conducts continuous lane-changing? (*1 = no extent at all to 5 = a great extent*)	[5,6,14,43–48]
Prototype Favorability (PF)	PF1. How favorable is your impression of the type of driver your age who regularly conducts continuous lane-changing? (*1 = very unfavorable to 5 = very favorable*) PF2 *. To what extent do you think a driver your age who regularly conducts continuous lane-changing is immature? (*1 = no extent at all to 5 = a great extent*) PF3 *. To what extent do you think a driver your age who regularly conducts continuous lane-changing is self-centered? (*1 = no extent at all to 5 = a great extent*) PF4. To what extent do you think a driver your age who regularly conducts continuous lane-changing is dynamic? (*1 = no extent at all to 5 = a great extent*) PF5. To what extent do you think a driver your age who regularly conducts continuous lane-changing is cool? (*1 = no extent at all to 5 = a great extent*)	[5,6,14,43–48]
Behavioral Willingness (BW)	*1 = "no extent at all" to 5 = "a great extent"* BW1. Suppose over the next month you are driving on an urban road worried about being late, but when approaching an intersection (see Figure 5a), you realize that you will miss the target lane unless you change lanes twice. To what extent would you be willing to conduct continuous lane-changing? BW2. Suppose over the next month you are driving on a freeway (see Figure 5b), but because of a distraction, you realize that you will miss the highway exit unless you change lanes twice. To what extent would you be willing to conduct continuous lane-changing? BW3. Suppose over the next month you are driving worried about being late (see Figure 5c), but the vehicles ahead of you and in the adjacent lane are all moving slowly. You need to change to a non-adjacent lane, to what extent would you be willing to conduct continuous lane-changing?	[5,6,14,43–48,56]

Note: * The scores of the items were reversed.

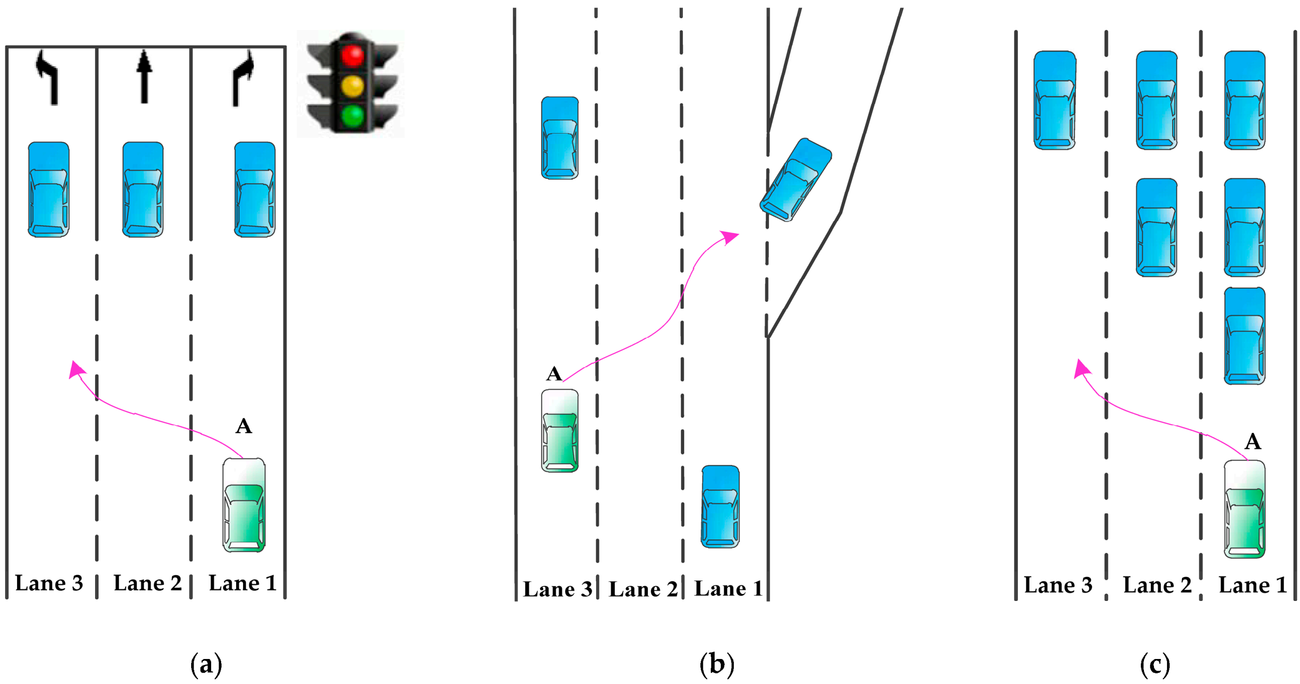

Figure 5. Driving scenarios of continuous lane-changing (Car A: the car you are driving), (**a**) near a signalized intersection, (**b**) near an exit ramp, (**c**) on a section of road.

2.3. Data Analysis

Descriptive statistics were used to reveal the demographic information of the participants and the characteristics of all the variables, and a correlation analysis was used to examine the relationships among all the variables. To test the internal consistency of the items, Cronbach's alpha (α) values were calculated, and explanatory factor analysis (EFA) was conducted to examine the underlying structure of the questionnaire. The above analyses were all carried out in SPSS 25.0.

The structural equation model (SEM) was used to test the models proposed in this study. SEM includes two parts: measurement and structural models [61–63]. For the measurement model, confirmatory factor analysis (CFA) was used to examine the relationship between the latent variables and their corresponding observation indicators. The standardized coefficients, average variance extracted (AVE), and composite reliability (CR) were calculated to test the convergent validity and construct reliability of the measurement model. The structural model was used for path analysis to test all proposed hypotheses. The fit indices of the measurement and the structural models were tested using a series of fit indices, such as the ratio of chi-square value to the degree of freedom (χ^2/df), Tucker–Lewis index (TLI), comparative fit index (CFI), incremental fit index (IFI), standardized root mean square residual (SRMR), and standardized root mean square residual (RMSEA). In general, it is recommended that $1 < \chi^2/df < 3$, TLI > 0.90, CFI > 0.95, IFI > 0.90, SRMR < 0.08, and RMSEA < 0.06 [61–63]. Due to the absence of the data normality, the maximum likelihood estimation method was used in conjunction with the bootstrapping procedure (using 1000 bootstrap samples) to estimate both the measurement and structural models. The above analyses were carried out in the statistical package AMOS version 24.0.

3. Results

3.1. Descriptive Analysis

Table 3 shows the participants' demographic information. The average age was 22.1 years (SD = 2.06) with an average driving experience of 2.66 years (SD = 1.48). Of the participants, 306 (63.6%) were male, and 175 were female (36.4%). The majority (48.0%) had a senior high school level of education, a few (30.2%) had at least an undergraduate university level of education, and the rest (21.8%) had less than a high school level of education. With regard to driving frequency, 29.3% drove 6–10 hours per week. The majority (45.3%) reported that they had not conducted continuous lane-changing in the previous 3 months.

Table 3. Profile of the participants.

Variables	Description	Frequency	%
Age	M = 22.1, SD = 2.06	—	—
Driving experience	M = 2.66, SD = 1.48	—	—
Gender	0 = "Male"	306	63.6
	1 = "Female"	175	36.4
Education background	1 = "Below high school"	105	21.8
	2 = "High school"	231	48.0
	3 = "Undergraduate and above"	145	30.2
Driving frequency (hours per week)	1 = "0−5"	91	18.9
	2 = "6−10"	141	29.3
	3 = "11−15"	101	21.0
	4 = "16−20"	72	15.0
	5 = ">20"	76	15.8
Past behavior	0 = "Never"	218	45.3
	1 = "Occasionally"	107	22.2
	2 = "Sometimes"	89	18.5
	3 = "Often"	46	9.6
	4 = "Very often"	21	4.4

The details of the participants' responses and descriptive analysis of all the items are presented in Table A1 in Appendix A. According to the analysis of all the constructs (see Table 4), the mean score of self-reported behavioral willingness was 2.04 (SD = 0.90), which indicated that most participants had a weak willingness for continuous lane-changing.

Table 4. Descriptive statistics and correlations.

Variables	1	2	3	4	5	6	7	8
1. AT	1							
2. SN	−0.32 **	1						
3. PBC	0.42 **	−0.26 **	1					
4. MN	−0.16 **	0.23 **	−0.22 **	1				
5. PR	−0.25 **	0.33 **	−0.38 **	0.14 **	1			
6. PS	0.22 **	−0.43 **	0.28 **	−0.17 **	−0.27 **	1		
7. PF	0.30 **	−0.31 **	0.44 **	−0.20 **	−0.35 **	0.36 **	1	
8. BW	0.43 **	−0.48 **	0.52 **	−0.24 **	−0.42 **	0.48 **	0.53 **	1
Mean	2.79	2.98	2.95	2.90	3.30	2.91	3.02	2.04
SD	0.86	0.96	1.00	0.87	0.97	0.86	0.85	0.90

Note: ** $p \leq 0.01$.

Pearson's correlation analysis results (see Table 4) showed that attitude (r = 0.43, p < 0.01), PBC (r = 0.52, p < 0.01), prototype similarity (r = 0.48, p < 0.01), and prototype favorability (r = 0.53, p < 0.01) were positively correlated with behavioral willingness, whereas subjective norms (r = –0.48, p < 0.01), moral norms (r = −0.24, p < 0.01), and perceived risk (r = −0.42, p < 0.01) were negatively correlated.

3.2. EFA Results

As shown in Table 5, the values of Cronbach's α (0.828–0.936) were all above 0.70, which indicated that the questionnaire had high reliability. The EFA results are shown in Table 5. Eight factors were extracted from the 30 items that explained 74.15% of the total variance. The factor loadings of items were all above 0.5 ranging from 0.684 to 0.928. Therefore, no items needed to be eliminated from the questionnaire.

Table 5. Cronbach's α values, EFA results, and CFA results.

Variables/Cronbach's α	Items	EFA [a]		CFA [b]			
		Loadings	% of Variance	Loadings	p–Value	CR	AVE
AT			9.568			0.844	0.576
Cronbach's α = 0.838	AT1	0.781		0.733	<0.001		
	AT2	0.737		0.695	<0.001		
	AT3	0.813		0.810	<0.001		
	AT4	0.820		0.791	<0.001		
SN			11.454				
Cronbach's α = 0.936	SN1	0.829		0.877	<0.001	0.949	0.825
	SN2	0.848		0.885	<0.001		
	SN3	0.844		0.908	<0.001		
	SN4	0.928		0.960	<0.001		
PBC			7.293			0.837	0.632
Cronbach's α = 0.836	PBC1	0.801		0.789	<0.001		
	PBC2	0.749		0.813	<0.001		
	PBC3	0.799		0.782	<0.001		
MN			7.564			0.829	0.619
Cronbach's α = 0.828	MN1	0.855		0.842	<0.001		
	MN2	0.816		0.746	<0.001		
	MN3	0.868		0.769	<0.001		
PR			10.487			0.894	0.679
Cronbach's α = 0.890	PR1	0.871		0.888	<0.001		
	PR2	0.877		0.890	<0.001		
	PR3	0.784		0.757	<0.001		
	PR4	0.777		0.750	<0.001		
PS			9.735			0.861	0.610
Cronbach's α = 0.855	PS1	0.827		0.847	<0.001		
	PS2	0.817		0.876	<0.001		
	PS3	0.727		0.674	<0.001		
	PS4	0.777		0.708	<0.001		
PF			11.062			0.849	0.531
Cronbach's α = 0.847	PF1	0.684		0.663	<0.001		
	PF2 *	0.737		0.727	<0.001		
	PF3 *	0.731		0.725	<0.001		
	PF4	0.753		0.672	<0.001		
	PF5	0.800		0.843	<0.001		
BW			6.987			0.917	0.786
Cronbach's α = 0.914	BW1	0.725		0.882	<0.001		
	BW2	0.784		0.933	<0.001		
	BW3	0.747		0.843	<0.001		

Note: [a] Extraction method: Principal component analysis; Rotation method: Varimax; Kaiser–Meyer–Olkin test (KMO = 0.884 > 0.5); Bartlet's test (χ^2 = 9234.800, df = 435, p = 0.000). [b] Model fit indices: χ^2/df = 1.578 (p = 0.000); TLI = 0.972; CFI = 0.976; IFI = 0.976, SRMR = 0.0365, RMSEA = 0.035. * The scores of the items were reversed.

3.3. Measurement Model Analysis Results

The CFA analysis results of Model 3 are also presented in Table 5. All the fit indices (χ^2/df, CFI, etc.) met the recommended criteria. The standardized factor loadings (see Table 4) of each observation index on its corresponding variable were all larger than 0.5, ranging from 0.663 to 0.960. CR was used to evaluate the structural validity of the data, and their values for the eight variables were all higher than 0.7, indicating that the observational indicators of each variable had a high degree of consistency. The AVE was used to evaluate the convergent validity, and the value of each variable was higher than 0.5 but lower than its corresponding CR value, which indicated that the model had good convergent validity.

In summary, the above results showed that the model was suitable for the next step of structural equation analysis.

3.4. Structural Model Analysis Results

Structural model analysis results of the three models are shown in Figure 6. All the fit indices of the three models satisfied the recommended criteria. With regard to Model 1, the PWM factors of attitude (β = 0.229, $p \leq 0.001$), prototype favorability (β = 0.363, $p \leq 0.001$), and prototype similarity (β = 0.246, $p \leq 0.001$) were all positively associated with behavioral willingness, while subjective norms (β = −0.160, $p \leq 0.001$) were negatively associated. As shown in Figure 6a, Model 1 explained a 52.2% variance in young drivers' willingness.

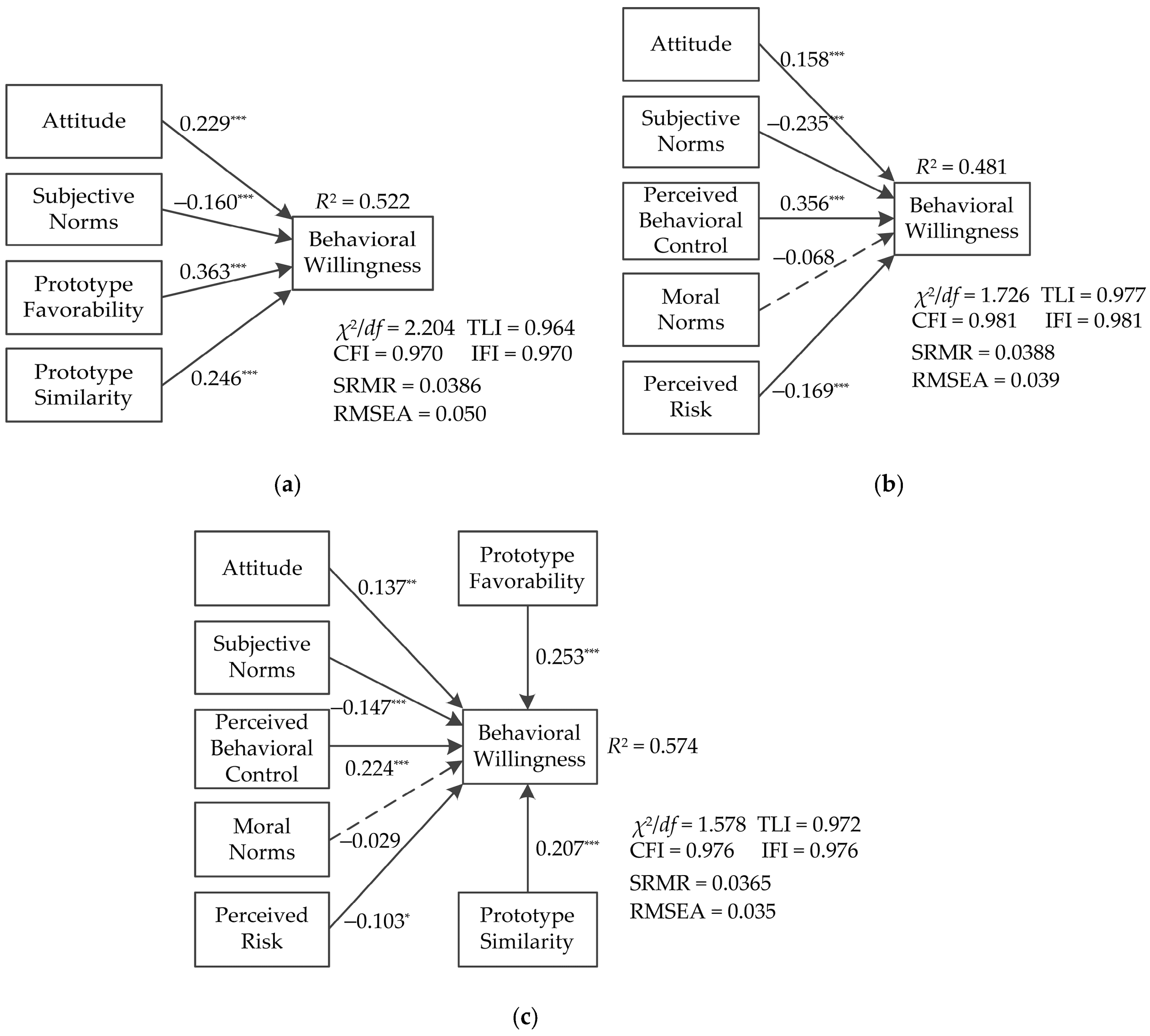

Figure 6. Structural model test results, (**a**) test results of Model 1, (**b**) test results of Model 2, (**c**) test results of Model 3, * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

For Model 2, as shown in Figure 6b, the TPB factors of attitude (β = 0.158, $p \leq 0.001$) and PBC (β = 0.356, $p \leq 0.001$) were both positively associated with behavioral willingness, while subjective norms (β = −0.235, $p \leq 0.001$) were negatively associated. The additional TPB factor of perceived risk (β = −0.169, $p \leq 0.001$) was significantly associated with behavioral willingness, while moral norms (β = –0.068, p = 0.104) were not. Model 2 explained a 48.1% variance in young drivers' willingness.

With regard to Model 3, as shown in Figure 6c, attitude (β = 0.137, p = 0.003), PBC (β = 0.224, $p \leq 0.001$), prototype favorability (β = 0.253, $p \leq 0.001$), and prototype similarity (β = 0.207, $p \leq 0.001$) were all positively associated with behavioral willingness. Subjective norms (β = −0.147, $p \leq 0.001$) and perceived risk (β = −0.103, p = 0.014) were both negatively associated, while moral norms (β = −0.029, p = 0.455) were not. Model 3 explained a 57.4% variance in young drivers' willingness.

Table 6 presents the hypotheses test results. As moral norms were not significantly associated with behavioral willingness in Model 2 and Model 3, Hypothesis H6 was not supported. According to path analysis results, H1–H5 and H7 were supported.

Table 6. Hypothesis test results.

Hypotheses	Paths	Mode 1		Mode 2		Mode 3	
		β	Results	β	Results	β	Results
H1	BW←AT	0.229 ***	Supported	0.158 ***	Supported	0.137 **	Supported
H2	BW←SN	−0.160 ***	Supported	−0.235 ***	Supported	−0.147 ***	Supported
H3	BW←PBC	—	—	0.350 ***	Supported	0.224 ***	Supported
H4	BW←MN	—	—	−0. 068	Not supported	−0.029	Not supported
H5	BW←PR	—	—	−0.169 ***	Supported	−0.103 *	Supported
H6	BW←PS	0.246 ***	Supported	—	—	0.207 ***	Supported
H7	BW←PF	0.363 ***	Supported	—	—	0.253 ***	Supported

Note: β (Standardized regression coefficients). * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

4. Discussion

This study is the first attempt to examine the factors influencing young drivers' willingness to conduct continuous lane-changing behavior, and it found that PWM and TPB were effective theoretical bases to explain young drivers' willingness, which gave rise to some theoretical contributions. Moreover, the PWM-TPB model was found to be superior to the PWM or TPB alone. The study enriched the scope and types of research on young drivers' risky behaviors, and also provided new ideas for improving and formulating policies and measures to address them.

As expected, the integrated PWM-TPB model supported the findings of previous studies [14,43,45,48] where combining PWM and TPB enhanced the predictive ability of the model. The PWM-TPB model explained 57.4% of the variance of young drivers' willingness to conduct continuous lane-changing: the PWM factors explained 52.2% of the variance, and the TPB factors explained 48.1%.

According to previous studies [4,6–11,13–16], attitudes had a significant influence on young drivers' intention to engage in risky or illegal behavior. In this study, Hypothesis 1 was supported by all three models where attitude was a significant influencing factor. This finding was also consistent with a previous study on drivers' lane-changing violations near urban intersections [29]. Some young drivers thought that continuous lane-changing would save time, bring them to their destinations faster, give them a sense of success, and not have an adverse effect on traffic. Young drivers with more positive attitudes toward continuous lane-changing behavior had a higher willingness to conduct this behavior.

In line with previous studies [4,6–8,10,13–16], Hypothesis 2 was supported by both Model 2 and Model 3, where the PBC was also a significant influence. Some young drivers were overconfident about their driving skills and believed that they could easily conduct continuous lane-changing and be able to deal with any emergency. The more self-control young drivers perceived, the higher the willingness to conduct continuous lane-changing behavior.

The subjective norm is a weak predictor in the TPB [52]. Brown et al. [9] showed that subjective norms did not affect young adults' intention to text while driving. However, our study found that subjective norms significantly affected young drivers' willingness to engage in continuous lane-changing. Other studies on young drivers reported similar results [4–8,10,12–16], which also confirmed that young drivers are more susceptible to the influence of family and friends.

Hypothesis 6, about moral norms having a significant effect on young drivers' behavioral willingness, was not supported by our study. The result was inconsistent with some previous studies [10–12,15], which showed that moral norms could predict young drivers' intention to text while driving. One possible explanation might be that some young drivers might not consider continuous lane-changing behavior to be as serious.

In line with previous studies [7–9], which reported that perceived risk was significantly associated with young drivers' intentions to drive while drowsy and text while driving, perceived risk was also a significant influence for young drivers' willingness to conduct continuous lane-changing. The less risk young drivers perceived, the higher was their willingness to engage in continuous lane-changing.

According to previous studies [14,48], young drivers' behavioral willingness could be predicted by prototype similarity and favorability. In this study, young drivers who strongly identified with the continuous lane-changing prototype had a strong willingness toward conducting this behavior. For young drivers, more favorable perceptions of the type of person who regularly conducts continuous lane-changing on roads were frequently associated with a greater willingness to engage in this behavior.

Many studies [64–70] have explored traffic injury prevention methods for young drivers, these indicated that campaigns, safety education, and enforcement are effective methods. Berg [67] suggested that both communication and increased enforcement should be used on young drivers, and young male drivers should be taken as the main target. Senserrick et al. [68] showed that resilience-focused young driver education programs were more effective than driver-focused programs in reducing road crashes. Bocina and Hasukic [69] demonstrated that campaigns and safety education programs could help to encourage responsible driving behavior among young drivers. Assailly [70] suggested that traffic safety education should enable students to participate more actively.

For young drivers, education programs should make them aware of the dangers of continuous lane-changing. Pictures, videos, and related crash cases might be used as publicity materials to improve the effects of safety education. Simulated driving is also a good way for them to appreciate the dangers of continuous lane-changing.

Previous studies [3,71–73] have also shown that the driving behavior and driving style of young drivers were greatly affected by their parents and peers, so they should be included in related education programs. Peer education is a useful tool in young driver safety interventions [74] that could also be adopted.

However, young drivers might be misled by the risky driving portrayed in Hollywood movies, motorsports, video games, or car advertisements. On the one hand, mass media campaigns, which have been effective for reducing illegal driving [75,76], could establish a positive example of safe, civilized driving through a celebrity endorsement. On the other hand, the negative image of continuous lane-changing should be identified, which might be useful for dissuading young drivers.

Previous studies [77–81] demonstrated that increased traffic enforcement could reduce traffic injury for drivers. Punishment for continuous lane-changing in places convenient for law enforcement such as signalized intersections and on- and off-ramps should be strengthened, for example, by adding dedicated cameras, warning signs, and markings.

5. Conclusions and Future Work

This study is believed to be the first to integrate the PWM and TPB to analyze young drivers' continuous lane-changing behavior. The findings of the study suggest that the PWM and TPB are useful for understanding the young drivers' willingness to engage in continuous lane-changing and that the integrated PWM-TPB model was found to be superior to the PWM and TPB in isolation. In the PWM-TPB model, attitude, subjective norms, PBC, perceived risk, prototype similarity, and prototype favorability were all found to be significant influencing factors. These findings demonstrated the significance of changing young drivers' attitudes, subjective norms, PBC, perceived risk, prototype similarity, and prototype favorability toward continuous lane-changing behavior. Therefore, more effective intervention measures can be designed, such as traffic safety education programs (picture and video warning, peer education, and simulated driving), mass media campaigns, and increased traffic enforcement.

Although our study's findings are important, they also have limitations that need to be addressed in future work. First of all, the sample size should be enlarged to make it more representative. Second, although influencing factors from both the TPB and PWM were used to explain young drivers' willingness, there might be other potential factors such as past behavior and driving habits [9,12,13,16]. Furthermore, in our study, self-reported questionnaire data were used to examine the factors behind young drivers' behavioral willingness, but the results may not have been entirely pertinent. Traffic accident data analysis helps to analyze the relationship between risky driving behavior and the cause and severity of traffic accidents. In future research, the relationship between continuous lane changing among young drivers and the occurrence of traffic accidents should be further studied.

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Data Availability Statement: All relevant data are within the paper.

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Appendix A

Table A1. Descriptive statistics of all items and the details of responses (N = 481).

	Items	M	SD	Skewness	Kurtosis	1(%)	2(%)	3(%)	4(%)	5(%)
AT	AT1	2.88	1.03	0.03	−0.64	8.7	28.7	33.7	24.1	4.8
	AT2	2.89	1.13	0.14	−0.68	11.4	26.6	33.3	19.3	9.4
	AT3	2.56	0.94	0.51	0.17	10.2	41.4	34.7	10.0	3.7
	AT4	2.86	1.09	0.41	−0.50	7.5	34.5	32.8	15.2	10.0
SN	SN1	3.14	1.08	−0.08	−0.57	7.1	20.0	36.4	25.4	11.2
	SN2	3.05	1.08	0.07	−0.59	7.1	23.9	36.6	21.8	10.6
	SN3	2.92	1.04	0.08	−0.46	8.7	25.2	38.5	20.4	7.3
	SN4	2.83	0.99	0.09	−0.39	8.9	27.9	39.1	19.3	4.8
PBC	PBC1	2.95	1.09	0.10	−0.59	8.7	26.0	35.6	21.0	8.7
	PBC2	2.82	1.22	0.14	−0.89	16.2	25.4	28.7	19.5	10.2
	PBC3	3.07	1.16	−0.08	−0.83	10.0	22.5	29.5	26.2	11.9
MN	MN1	2.80	0.97	−0.24	0.28	7.1	32.4	38.9	16.4	5.2
	MN2	2.85	1.02	−0.42	0.27	7.3	32.0	36.0	18.1	6.7
	MN3	3.04	1.04	−0.67	0.16	4.8	28.5	33.7	23.7	9.4

Table A1. *Cont.*

	Items	M	SD	Skewness	Kurtosis	1(%)	2(%)	3(%)	4(%)	5(%)
PR	PR1	3.74	1.11	−0.48	−0.83	1.7	15.8	20.0	32.0	30.6
	PR2	3.59	1.14	−0.26	−0.95	2.7	16.0	28.7	24.3	28.3
	PR3	2.96	1.14	0.04	−0.73	10.8	24.5	32.6	22.2	9.8
	PR4	2.92	1.11	0.04	−0.69	10.8	25.4	33.1	22.7	8.1
PS	PS1	2.83	0.99	0.09	−0.50	10.4	16.6	41.6	24.9	6.4
	PS2	2.87	1.03	0.16	−0.57	15.8	25.6	30.1	20.2	8.3
	PS3	2.85	1.06	0.16	−0.62	5.4	25.4	33.3	24.7	11.2
	PS4	3.08	1.03	−0.05	−0.55	6.7	27.2	34.9	24.3	6.9
PF	PF1	3.00	1.05	−0.22	−0.37	10.4	16.6	41.6	24.9	6.4
	PF2 *	2.80	1.17	0.12	−0.83	15.8	25.6	30.1	20.2	8.3
	PF3 *	3.11	1.07	0.06	−0.71	5.4	25.4	33.3	24.7	11.2
	PF4	2.98	1.03	0.06	−0.59	6.7	27.2	34.9	24.3	6.9
	PF5	3.16	1.08	−0.07	−0.65	6.2	21.2	34.1	26.6	11.9
BW	BW1	2.09	0.95	0.86	0.69	28.7	43.5	20.6	4.8	2.5
	BW2	1.85	1.01	1.40	1.92	45.1	34.7	14.6	1.2	4.3
	BW3	2.19	0.98	1.00	1.07	22.8	48.7	19.8	4.56	4.2

Note: * The scores of the items were reversed.

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